Three Essays in International Trade

Dissertation
for the Faculty of Economics, Business Administration and Information Technology of the University of Zurich

to achieve the title of
Doctor of Philosophy
in Economics

presented by

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approved in April 2011 at the request of
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Zurich, April 6, 2011

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Preface

The time I spent as a doctoral student at the University of Zurich and at Harvard University was one of great inspiration and was full of new insights. First and foremost my thanks go to my advisor Josef Zweimüller. To me he is a great co-author, discussion partner, and friend. Moreover, it was only the generous employment at his chair combined with greatest possible scientific freedom that allowed me to pursue my doctoral studies. Secondly, I owe to the team of the Chair of Macroeconomics: Jean-Philippe Wüllrich, Tanja Zehnder, Reto Foellmi, Tobias Würgler, Simone Gaillard, Claudia Bernasconi, Andreas Kuhn, Simon Büchi, Andreas Kohler, Bea Brunner, Sandro Favre, Katrin Koller, Oliver Ruf, Manuel Oechslin, and all the student assistants. Over lunch or during coffee breaks we often had very inspiring discussions about research questions and current events, but also very entertaining deliberations about all types of trivia. We all became close friend thanks to bike- and skitours, poker nights, and staff outings.

I want to thank Marc Melitz, who invited me to Harvard as a Visiting Fellow. His door was always open for me and in particular the chapter "Per capita incomes and the extensive margin of bilateral trade" benefited a lot from his comments and suggestions. Moreover, I am very grateful for his advice about my future career. I also owe to Fabrizio Zilibotti who is co-advisor for this dissertation.

Dana Sisak's company was essential for me. Without her encouragement, distraction and her wonderfully happy nature my life would have been much less fulfilled and I am quite sure that I would not have finished this dissertation without her. I am also very grateful to my friends – Cyril, Dani, Este, Heini, Jonas, Witschi, and all the great friends in Switzerland and Boston that I am not mentioning here.

Last, but not least I want to thank my family. My mother, Marguerite Hepenstrick-Koopman, was there for me in good and in difficult times. With her positive attitude to life she was always an important role-model to me. With my father, Konrad Hepenstrick, I had many interesting and refreshing discussions over lunch or extended coffee breaks. His advice was also pivotal for my decision to start the doctoral studies. My brother, Daniel Hepenstrick, was and still is a great friend and I was fascinated by the insights into the world of biology that he gave me. Finally I thank my grandparents, Susanne and Heinrich Hepenstrick. It is particularly noteworthy that my grandfather (a food chemist) is probably one of the few persons, who actually read a paper of mine literally from the first to the last word.

Die Zeit, welche ich als Doktorand an der Universität Zürich und der Harvard University verbracht habe, war äusserst inspirierend und voller neuer Erkenntnisse. Mein Dank geht zuerst an meinen Doktorvater Josef Zweimüller. Als grossartiger Koautor, Diskussionspartner und Freund hat er massgeblich zu meinem Doktorat beigetragen. Darüber hinaus war es erst eine grosszügige Anstellung an seinem Lehrstuhl verbunden mit grösster wissenschaftlicher Freiheit, welche mir das Doktoratsstudium überhaupt ermöglichte. Zweitens möchte ich mich beim Team des Lehrstuhl Zweimüller's bedanken: Jean-Philippe Wüllrich, Tanja Zehnder, Reto Foellmi, Tobias Würgler, Simone Gaillard, Claudia Bernasconi, Andreas Kuhn, Simon Büchi, Andeas Kohler, Bea Brunner, Sandro Favre, Katrin Koller, Oliver Ruf, Manuel Oechslin und alle Semesterassistenten. Gemeinsame Mittagessen und Kaffeepausen führten oft zu sehr inspierenden Diskussionen über aktuelle Forschungsfragen, allgemeines Zeitgeschehen, aber auch allerlei unterhaltsame Trivia. Durch gemeinsame Velo- und Skitouren, Pokerabende, und Lehrstuhlausflüge wurdet Ihr zu persönlichen Freunden. Vielen Dank!

Weiter möchte ich mich bei Marc Melitz bedanken. Er hat mich als Visiting Fellow für ein Jahr an die Harvard University eingeladen. Dort stand seine Türe immer offen, um meine Forschung zu besprechen. Insbesondere bei der Arbeit an dem Kapitel "Per capita incomes and the extensive margin of bilateral trade" habe ich stark von seinen Kommentaren und Vorschlägen profitiert. Darüber hinaus bin ich auch äusserst dankbar für die gemeinsamen Diskussionen über meine zukünftigen Karrieremöglichkeiten. Ich möchte mich auch bei Fabrizio Zilibotti bedanken für seine Bereitschaft mir als Koreferent zur Seite zu stehen.

Dana Sisak hat mich über weite Teile meiner Dissertation begleitet und ohne ihre Ermunterungen, Ablenkung und ihr wunderbar fröhliches Wesen wäre mein Leben viel weniger erfüllt gewesen. Ich bin sicher, dass ich ohne sie das Projekt einer Dissertation wohl frühzeitig abgebrochen hätte. Grosse Dankbarkeit geht auch auch an meine Freunde – Cyril, Dani, Este, Heini, Jonas, Witschi und alle weiteren an dieser Stelle nicht genannten Freunde und Freundinnen aus der Schweiz und aus Boston.

Schliesslich möchte ich mich bei meiner Familie bedanken. Meine Mutter, Marguerite Hepenstrick-Koopman, war sowohl in guten wie auch in schwierigen Zeiten für mich da und war mir mit ihrer positiven Lebenseinstellung immer ein wichtiges Vorbild. Mit meinem Vater, Konrad Hepenstrick, hatte ich viele interessante und erfrischende Diskussionen während längeren Kaffeepausen und gemeinsamen Mittagessen. Darüber hinaus war er mit seinem Rat massgeblich an meiner Entscheidung zum Doktoratsstudium beteiligt. Mein Bruder, Daniel Hepenstrick, war und ist mir ein Freund und bot mir faszinierende Einblicke in die Welt der Biologie. Meine Grosseltern, Susanne und Heinrich Hepenstrick, verdienen hier auch Erwähnung – nicht zuletzt aufgrund der Tatsache, dass mein Grossvater (ein Lebensmittelchemiker) wohl einer der wenigen Menschen ist, welche absolut vollständig eine Arbeit von mir durchgearbeitet haben!

Christian Hepenstrick, Pontresina, December 2010

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Chapter 1

Introduction

This dissertation's overarching theme is the economics of international trade between countries of different income levels. Average income is one of the the most prominent measures for the economic success of a country and the variation in average incomes across countries is a well known - and often deplored - feature of the global economy. Consider for example the average American's real income which is 50 times higher than the income of his peer in the Central African Republic (this corresponds to comparing the 10th richest with the 10th poorest country's income in a 2007 sample of 188 countries) or Switzerland's per capita income which is 33 times higher than Ethopia's (15th richest vs. 15th poorest country). In the context of international trade this large variation implies that the typical trade relation is one between two countries with very different income levels. Indeed, if one ranks the trade relations by the ratio of the rich partners' income relative to the poor partners' income one finds that the the median trade relation is one where the richer country's income is 4 times larger than the poorer country's income. The 25-percentile relation features a ratio of 2 and even in the 10-percentile relation the average income of the richer country is still 50% higher than the poorer country's income. The first two essays in this dissertation investigate how this asymmetry in incomes affects the pattern of trade.

The *first essay* starts with the simple observation that the number of different goods that are traded between two countries, henceforth called the extensive margin of bilateral trade, correlates positively with both the exporter's and the importer's per capita income. With respect to the exporting country this is reminiscent of a very standard Ricardian mechanism. If a country has an advanced technology it is competitive in many industries and therefore tends to export a broad set of different goods. At the same time a good technology implies that the factors are relatively productive and are correspondingly highly remunerated. Thus the positive correlation between the extensive margin and the exporter's per capita income. However, such a Ricardian framework leads almost immediately to the conclusion that the correlation between the importer's income and the extensive margin should be negative. After all, having a good technology and therefore being competitive in many industries implies that a country only needs to import a relatively narrow set of goods. I argue in the first essay that this simple model misses a crucial feature of consumer behavior – richer agents not only consume higher quantities, but also a broader set of different goods. I.e. they adjust their extensive margin of consumption. It may well be that a country with a good technology tends to produce more goods locally, but this effect can be dominated by this country's consumers demanding a broader set of goods. I formalize this intuition by adapting the modern workhorse model of quantitative trade theory and allowing consumers to adjust the set of goods that they consume. Quantifying the model allows me to assess the relative importance of the two channels. I find that the demand side channel, i.e. an expanding extensive margin of consumption, dominates and that the income elasticities of the model are reasonably close to the empirical elasticities. Together with a number of extensions and robustness checks I conclude this first essay with two counterfactual experiments that demonstrate that it is quantitatively important to account for this newly identified demand side channel.

This first essay keeps the supply side very simple for the sake of parsimony. In particular I assume perfectly competitive goods markets, which ensures tractability of the multi-country model. In the *second essay* my co-authors, Reto Foellmi and Josef Zweimüller, and I analyze the additional effects that arise in the context of a more complex market structure. We adapt a stylized two country model and document that in the presence of market power producers find it optimal to price discriminate across markets by setting high (low) prices in rich (poor) countries. However, the threat of international arbitrage in the form of parallel trade leads firms to charge a price in the rich country that is lower than what they would charge in the absence of the threat of parallel trade. This opens up the possibility of an alternative strategy – forgoing the relatively small operating profit that is realized in the poor country and focusing on the rich market only allows the producers to charge a high price in the rich country without having to fear arbitrageurs. This strategy's attractiveness and therewith the set of firms following this strategy rises in the degree of inequality of the trading partners incomes. The extensive margin of trade is given by the measure of exporting firms relative to the total measure of firms. In the presence of market power it is therefore not only the absolute level of the trading partners' incomes that is relevant for the extensive margin of trade, but also the relative incomes of the trading partners. Moreover, we show that this novel channel biases the gains from trade toward rich countries. We extend our model to more than two countries; to unequal incomes within countries; and to more general specifications of non-homothetic preferences. The basic results are robust to these extensions.

The first two essays are concerned with the effect of differences in per capita incomes on the pattern of trade. The *third essay* provides a different angle. It asks if the very fact that countries engage in trade affects the variation in incomes across countries. In order to investigate this question I use a standard quantitative trade model as a development accounting tool. I quantify this model combining data on bilateral trade pattern with country-specific endowment data. I then perform a number of counterfactual experiments that allow me to disentangle the roles that the different elements of the model play in determining the cross-sectional variation in average incomes. I find that asymmetries in trade cost – fixed market entry costs and variable transportation costs – may explain around 20% of the variation in per capita incomes, which is a relatively small number compared to the effects of asymmetries in endowments. After several robustness checks I apply the model to Switzerland and attempt at determining the origins of the Swiss gains from trade. Not surprisingly, I find that most gains are due to the close-by countries and the US and China. More unexpected are the results of counterfactual experiments that put a number on the average Swiss consumer's willingness to pay for trade being possible between Switzerland and a particular country. Due to reallocation effects the thus measured welfare-losses are rather small. I use this result to conclude with a word of caution about the nature of the experiments performed in modern trade models.

Chapter 2

Per capita incomes and the extensive margin of bilateral trade

2.1 Introduction

Trade flows greatly vary in the number of different goods that are traded between countries. This "extensive margin of bilateral trade" can be thought of as the manifestation of an interplay of the exporter's production technology, the importer's demand structure, and bilateral trade costs - it is more likely that two countries trade a given good if the exporter is particularly strong in producing this good, the importer has a especially high demand for that good, or bilateral trade barriers are low. Most existing analyses of the extensive margin of bilateral trade focus on the exporter's technology and bilateral trade costs. This chapter provides a complementary perspective by emphasizing the role of the importing country's demand structure.

For this purpose I adapt the Ricardian multi-country model by Eaton and Kortum (2002) (henceforth EK). In the EK framework the production technology is country-variety specific. Together with trade costs this determines the price at which a supplying country can offer a variety in a particular destination market. In any given destination market the producer country offering the lowest price will be the sole supplier of this variety. However, whether this trade flow then actually materializes depends not only on the supplier country's good technology and low bilateral trade costs, but crucially also on the importing country's demand structure - particularly if at the price offered there is actually a positive demand for this variety. With the traditional CES preferences demand is always positive since the marginal utility is unbounded. In this chapter I relax this assumption and allow agents to adjust the set of goods they purchase - henceforth called the "extensive margin of consumption" - with income.[1] In choosing their optimal consumption bundle agents order the varieties along their prices and decide up to which price it is optimal to consume positive quantities. It therefore is possible that for a given variety the lowest price offered by the supplier countries is still too high and the agents in the importing country find it optimal not to consume (and therefore not to import) this variety. The corresponding model is developed in Section 2.2.

A thus extended model helps to make sense of the empirical behavior of the extensive margin of trade. It has been documented in several studies that richer countries both import and export more varieties (see e.g. Hummels and Klenow (2002), Baldwin and Harrigan (2007), or Sauré (2009)). Table 2.1 summarizes these findings by regressing the extensive margin of bilateral trade in consumption goods[2] on the per capita incomes and population sizes of the trading partners (controlling for bilateral resistance). The positive elasticity of exporter per capita income can be understood as a standard Ricardian mechanism: per capita income is high due to a country's good technology. But being technologically advanced implies that this country is competitive in many industries and therefore tends to export a broad set of varieties. However, at the same time this implies that the number of varieties that need to be imported is relatively low. Allowing for the extensive margin of consumption to adjust with income generates a countervailing force.

In order to assess whether this force is strong enough to dominate the negative effect coming from the supply side I quantify the model in Section 2.3. I use the aggregate

[1] Jackson (1984) documented the empirical relevance of the "extensive margin of consumption" using US consumer expenditure data. Falkinger and Zweimüller (1996) provide evidence that richer countries consume a broader set of goods using the Worldbank's ICP-data. Other studies documenting positive correlations between variety and income include Jekanowski and Binkley (2000), Moon, Florkowski, Beuchat, Resurreccion, Paraskova, Jordanov, and Chinnan (2002), and Thiele and Weiss (2003) for food consumption and Gronau and Hamermesh (2008) documenting similar effects in time use data.

[2] I consider consumption goods only since the channel proposed in this chapter affects the patterns of final demand only.

Table 2.1: Dependent variable - extensive margin of bilateral trade

	variable	coefficient
per capita income	exporter	0.66^{***}
	importer	0.47^{***}
population size	exporter	0.65^{***}
	importer	0.30^{***}
bilateral distance	$[375, 750)$	-0.78^{***}
	$[750, 1500)$	-1.49^{***}
	$[1500, 3000)$	-2.26^{***}
	$[3000, 6000)$	-2.50^{***}
	$[6000, \infty)$	-2.88^{***}
additional controls	shared border	0.45^{***}
	same language	0.74^{***}

$N = 16053$, $R^2 = 0.63$, *** implies significance at the 1%-level

values of bilateral trade flows to estimate the model's technologies and trade costs and data on US consumer expenditure to pin down the preference parameters. I then simulate the thus calibrated model and consider the behavior of its extensive margin of bilateral trade. I find that the demand side forces are sufficiently strong to dominate the negative effect of a good technology on the extensive margin of imports. Comparing the income elasticities of the extensive margin of bilateral trade to the data I find that they are of the right sign and close to the empirical elasticities.

What is the quantitative importance of this new demand side channel? To answer this question I use the calibrated model to perform two classical counterfactual experiments - lowering trade costs and the rise of China and India. A traditional model neglecting the demand side predicts that lower trade costs lead to higher extensive margins of trade since trade becomes worthwhile for more varieties. This effect is reinforced by the demand side. Lower trade cost lead to higher real incomes which induces agents to expand their extensive margins of consumption. This then increases the number of traded varieties. Quantitatively I find that the predicted increases in the extensive margins of bilateral trade flows are at least twice as high when allowing for the extensive margin of consumption to adjust. The second experiment considers the effect of technological progress in China and India. Better local technologies imply that these countries will tend to produce more varieties locally since they become more competitive. However, the rising incomes will lead consumers to expand the measure of varieties that they consume. This effect dominates and therefore the model with non-homothetic preferences predicts that the extensive margin of imports is rising, whereas a model neglecting demand side effects would actually predict falling extensive margins.

In this chapter I use the EK framework since it is parsimonious in the context of my objective - it allows me to develop my argument in a very intuitive way and nevertheless provides me with a model that is general enough to be directly quantified. The message of the demand side being an important determinant of the extensive margin of trade however is more general. In Section 2.4 I discuss how the demand side effects would play in a model of monopolistic competition and heterogeneous firms and what additional effects and complications may emerge. Remaining in the Ricardian framework Section 2.5 discusses a number of extensions. First, I show that accounting for trade in intermediates does not significantly change the quantitative predictions of the model. Second, I consider the implications of allowing for within-country inequality, and third I show that the results are not driven by the particular functional form of the utility function. Section 2.6 concludes.

This chapter contributes to two strands of the trade literature. First, by highlighting the role of the importer's demand structure it contributes to the broad literature investigating the extensive margin of trade. Second, on a more theoretical side it contributes to the growing literature that recognizes the potential importance of non-homothetic consumer behavior for understanding different aspects of trade pattern. The focus of previous contributions was on how non-homothetic consumer behaviour help us to understand variations in the aggregate values of trade flows and differences in unit prices[3], whereas this study focuses on the extensive margin of trade. As for the aggregate values of trade flows Fieler (2010) argues that non-homothetic preferences help to explain the higher trade share of rich countries. She extends the EK model to two industries with

[3]For a more complete overview of the literature of non-homothetic preferences and trade see Markusen (2010).

differing demand elasticities. Richer countries then relatively concentrate their expenditures in the high-elasticity industries. If the variability in productivities across countries is relatively high in these industries, their share of traded output will be high. Together with the demand pattern this implies that rich countries' trade shares are higher. With respect to the extensive margin of trade however, her model's predictions are similar to EK (a negative correlation of per capita income and the extensive margin of imports) since agents do not adjust their extensive margin of consumption. Another aspect of trade pattern where non-homotheticity is potentially relevant is the variation in unit-prices across importing countries. Simonovska (2010) argues that differences in unit prices reflect differing markups due to demand elasticities that change with income. Choi, Hummels, and Xiang (2009) and Fajgelbaum, Grossman, and Helpman (2009) on the other hand understand differences in unit-prices as reflecting quality differences due to a increasing taste for quality with rising income. Concerning the extensive margin of trade Sauré (2009) argues that richer countries have more trading partners (county level extensive margin) due to non-homothetic preferences and Foellmi, Hepenstrick, and Zweimüller (2010) show that non-homothetic preferences can generate incentives for parallel trade and influence the extensive margin of trade via this channel. This chapter's contribution is a multi-country model of trade where the importing country's consumers decide about their extensive margin of consumption. This decision then determines together with the exporters technologies and the structure of trade costs the extensive margins of bilateral trade flows.

2.2 A model of per capita incomes and the extensive margin

The world economy consists of N countries. Country i's population is denoted by L_i. Each agent is endowed with one unit of labor that is inelastically supplied on the domestic market. There is one industry producing differentiated consumption goods. The measure of varieties is exogenous and normalized to one.

2.2.1 Consumer behavior

Agents maximize the same symmetric additively separable utility function

$$U = \int_0^1 v\left(x\left(j\right)\right) dj$$

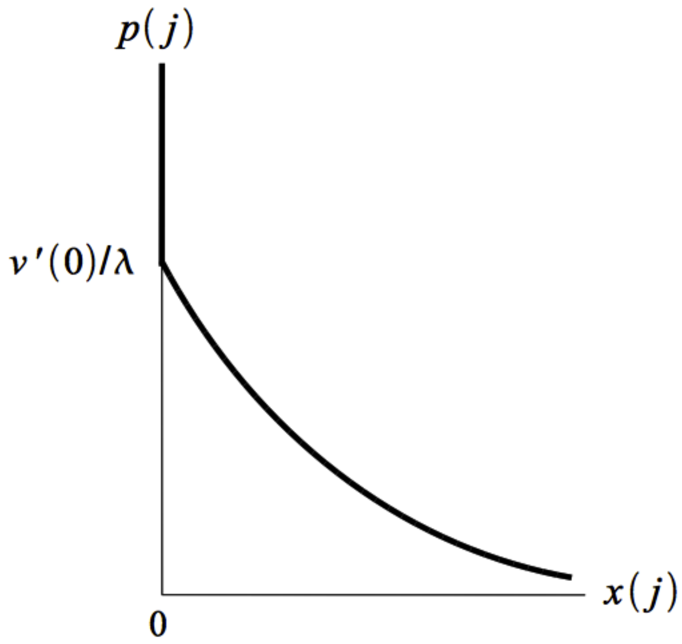
subject to their budget constraints $E \geq \int_0^1 p\left(j\right) x\left(j\right) dj$ and the non-negativity constraints $x\left(j\right) \geq 0 \; \forall \; j$. E denotes an agent's income. The sub-utility function $v\left(x\right)$ is concave, $v'\left(x\right) > 0$ and $v''\left(x\right) < 0$, and the marginal utility is bounded from above, $v'\left(0\right) < \infty$. With bounded marginal utility the non-negativity constraints are potentially binding and the corresponding first order conditions for a variety j are

$$\begin{aligned} v'\left(x\left(j\right)\right) &= \lambda p\left(j\right) \quad \text{for } x\left(j\right) > 0 \\ v'\left(0\right) &< \lambda p\left(j\right) \quad \text{for } x\left(j\right) = 0 \end{aligned} \tag{2.2.1}$$

where λ is the Lagrange multiplier. Intuitively, an agent compares for every available variety j the marginal utility from starting to consume this variety $v'\left(0\right)$ with her utility costs $\lambda p\left(j\right)$ associated with buying a marginal unit of this variety. If the marginal costs are higher than the marginal utility the optimal quantity is zero - the non-negativity constraint binds. For all other varieties the optimal quantities are positive and are chosen such that the marginal rates of substitution equal relative prices. Figure 2.1 depicts the demand function for a particular variety j. Note that there is a finite price $v'\left(0\right)/\lambda$ above which the optimal quantity is zero.

As the varieties enter the utility function symmetrically, agents simply order the varieties in their prices (think of reindexing the varieties such that the prices rise in the index j) and then choose up to which price they still want to consume positive quantities. I denote the index of this marginal variety by M. Its price follows from rearranging the first order condition (2.2.1) when the non-negativity constraint just binds, $p\left(M\right) = v'\left(0\right)/\lambda$. As the indices are increasing in prices, M also denotes the measure of varieties that are consumed in positive quantities and thus represents the *extensive margin of consumption* in this model. Because the goods spectrum is normalized to one the extensive margin

Figure 2.1: Demand function



of consumption simultaneously represents the share of available varieties consumed in positive quantities.

Assuming that the price distribution can be represented by a continuous cdf $G(p)$ - this will be the case in the general equilibrium - the share of consumed varieties (and therefore also the extensive margin of consumption) is

$$M = G\left(v'\left(0\right)/\lambda\right). \tag{2.2.2}$$

For varieties $j < M$ the Marshallian demand follows from rearranging the first order condition, $x\left(\lambda p\right) = v'^{-1}\left(\lambda p\right)$. Inserting the Marshallian demand into the budget constraint and making the change of variable $p = G^{-1}\left(j\right)$ yields

$$E = \int_{0}^{v'(0)/\lambda} px\left(\lambda p\right) g\left(p\right) dp \tag{2.2.3}$$

implicitely determining the marginal utility of income λ for a given price distribution $G(p)$ and income E. In the equilibrium we will know the price distribution and the income and thus be able to solve for the multiplier λ. Using (2.2.2) one then solves for the extensive margin of consumption and (2.2.1) determines the optimal quantities for varieties $j < M$.

The potentially binding non-negativity constraints contrast with previous EK models (see for example EK and Fieler, 2010) that assumed CES preferences.[4] The unbounded marginal utility of CES preferences implies that in this class of models agents always consume all varieties, $M = 1$, independent of the price distribution and income.

2.2.2 Production technology and market structure

The supply side of the model is similar to the basic EK framework: The production technology exhibits constant returns to scale and uses one input[5], which I call labor. Labor is assumed to be perfectly mobile within countries, but immobile across countries, so that in equilibrium there will be one wage rate w_i per country. $z_i(j)$ denotes country i's productivity in producing variety j. Assuming perfect competition and iceberg trade costs[6] - d_{ni} units need to be shipped in i for one unit to arrive at the destination n - implies that the price at which country i offers variety j in country n is

$$p_{ni}(j) = \frac{w_i d_{ni}}{z_i(j)}. \tag{2.2.4}$$

The country-variety specific productivity $z_i(j)$ is the realization of a Fréchet distributed random variable $Z_i(j)$

$$\Pr[Z_i(j) \leq z] = \exp\left\{-T_i z^{-\theta}\right\},$$

where T_i is country specific and governs the expected productivity draw. I will therefore refer to T_i as country i's technology (a higher T_i implies a higher expected productivity and therefore represents a better technology in country i). θ is common to all countries

[4]Fieler (2010) models two industries with differing elasticities of substitution. Agents therefore adjust their relative expenditures across industries with income and thus exhibit non-homothetic consumption pattern. However, since the marginal utility is unbounded the agents do not adjust the sets from which they consume, i.e. all agents always consume in both industries all varieties.

[5]For parsimony I abstain from modeling multiple inputs. This will imply that in the calibration differences in non-tradable endowments (e.g. human and physical capital) and differing price-indices for tradable intermediates are absorbed into the calibrated technology. For non-tradable endowments and in the context of the counterfactuals this is admissible. For tradable intermediate inputs I will show in the robustness-section how the results change when allowing for them.

[6]I normalize trade costs within countries to one, $d_{nn} = 1$ for all n, and assume that the triangle inequality, $d_{ni} \leq d_{ki} d_{nk}$ holds for all i, k, and n.

and controls the variation in the productivities (the lower θ the more variation there is in productivity draws). I will show later on that θ also governs the elasticity of trade volumes with respect to trade cost, which is why I sometimes will call θ the trade elasticity.

2.2.3 Equilibrium

All countries i are in principle able to produce each variety j. However, consumers will source each variety from only one producing country - the country offering the lowest price. International trade thus emerges if this country with the lowest price is a foreign country. In the appendix I show that the lowest prices on offer in country n can be represented by a cdf

$$G_n(p) = 1 - \exp\left\{-\Phi_n p^\theta\right\}, \tag{2.2.5}$$

where

$$\Phi_n = \sum_{i=1}^{N} T_i \left(w_i d_{ni}\right)^{-\theta}.$$

I.e. $G_n(p)$ represents the share of varieties in country n with a price (weakly) below p. As all agents are endowed with one unit of labor the income of a country n agent is simply the wage rate, w_n (to be endogenously determined). For a given wage rate the budget restriction (2.2.3) together with the price distribution therefore determines the marginal utility in country n, λ_n. The extensive margin of consumption in n follows immediately,

$$M_n = 1 - \exp\left\{-\Phi_n \left(v'(0)/\lambda_n\right)^\theta\right\}. \tag{2.2.6}$$

In the appendix I derive the probability π_{ni} that a producer country i is the cheapest supplier in the importing country n for a particular variety,

$$\pi_{ni} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\Phi_n}.$$

Since there is a continuum of goods, π_{ni} is also the share of varieties for which country i is the cheapest supplier in n. Because the probability is the same for all goods π_{ni} is not only the share of the total goods spectrum, but also the share for any sub-spectrum;

in particular also for an importing country's extensive margin of consumption. But this implies that the *extensive margin* of the *bilateral trade flow* from i to n, which I denote by m_{ni}, is simply the importing country's extensive margin of consumption, M_n, multiplied by the share of varieties for which the exporter i is the cheapest producer, π_{ni},

$$m_{ni} = \pi_{ni} M_n. \tag{2.2.7}$$

The source of the remarkable simplicity of this result is worth discussing: The distributional assumption of the EK framework implies that conditional on entering a market n prices have the same distribution across supplier countries (the appendix provides the corresponding derivations).[7] Therefore the prices of the goods that the importer n actually buys bear no information about the likely source of these goods, so that π_{ni} is the share of varieties of any subinterval of the variety space for which the supplier i offers the cheapest price in n - in particular also for the subinterval M_n representing the M_n percent cheapest varieties.

Since the distribution of prices of goods that are actually sold in n is the same across supplier countries i, average sales do not vary by source neither. In particular, average sales in n are given by total expenditures $w_n L_n$ divided by the extensive margin of consumption, $w_n L_n / M_n$. The aggregate value of the bilateral trade flow from i to n, X_{ni} is given by average sales multiplied by the the measure of varieties for which i is the cheapest supplier in n and which are actually consumed in positive quantities - the extensive margin of trade, m_{ni} - which yields

$$X_{ni} = \pi_{ni} w_n L_n. \tag{2.2.8}$$

Note that taking the derivative of the log of volumes with respect to the log of trade costs yields θ (neglecting general equilibrium effects on the wage rates) which is why θ is

[7] Eaton and Kortum (forthcoming) call this feature "neutrality". Note that neutrality is not unique to the Ricardian framework. E.g. in the monopolistic competition model with heterogeneous firms and market entry costs neutrality follows if market entry costs are only destination specific and productivities are drawn from Pareto distributions. Costinot and Komunjer (2007) provide a discussion of general productivity distributions in the Ricardian multi-country framework.

sometimes called the trade elasticity.

To close the model and determine the equilibrium wage vector I use the labor market clearing conditions[8]

$$w_i L_i = \sum_{n=1}^{N} \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} T_k \left(w_k d_{nk}\right)^{-\theta}} w_n L_n \qquad \text{for } i = 1, ..., N. \tag{2.2.9}$$

In summary, the structure of the global economy is characterized by the countries' technologies, T_i, and populations, L_i, the matrix of bilateral trade costs, d_{ni}, the trade elasticity, θ, and the shape of the utility function, $v(\cdot)$. In the general equilibrium producers price according to (2.2.4) and consumers choose their optimal quantities and extensive margins (2.2.6) as implied by (2.2.1). Market clearing (2.2.9) pins down the set of equilibrium wage rates and bilateral trade pattern are characterized by their aggregate value (2.2.8) and their extensive margin (2.2.7).[9]

2.2.4 The role of per capita incomes

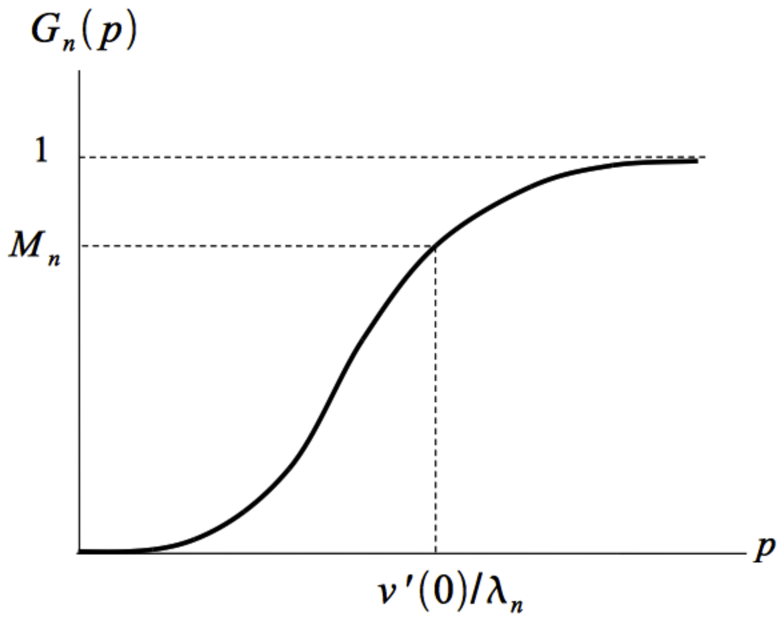
In this section I discuss how per capita incomes affect trade pattern and contrast the results to the standard model with homothetic preferences.[10] In the context of this chapter the role of non-homothetic preferences is to endogenize the extensive margin of consumption. Figure 2.2 illustrates this by depicting equation (2.2.6). The price of the marginal variety is $v'(0)/\lambda_n$. Using the country specific price distribution $G_n(p)$ one gets the share of varieties with prices lower than this marginal price and thus the share (and measure)

[8] The labor market clearing condition follows for example from imposing balanced trade, $\sum_{k\neq i} X_{ik} = \sum_{n\neq i} X_{ni}$, and adding the domestically sourced consumption, X_{ii}, on both sides to get $\sum_{k=1}^{N} X_{ik} = \sum_{n=1}^{N} X_{ni}$. Total expenditures in i are $w_i L_i = \sum_{k=1}^{N} X_{ik}$. Substituting for X_{ni} and π_{ni} on the right hand side then yields the labor market clearing condition as stated in the text.

[9] The general equilibrium exists and is unique. To see this note that the labor market clearing conditions can be rewritten as excess demands for labor. It is straight forward to show that the resulting system of excess demands satisfies the sufficient properties for existence and uniqueness (see for example Propositions 17.B.2 and 17.F.3 in Mas-Colell, Whinston, and Green (1995)). The extensive margins and the optimal quantities are unique as they follow from maximizing a concave object over a convex constraint. As wages and extensive margins fully summarize the general equilibrium this implies that the general equilibrium is unique.

[10] With homothetic preferences expenditure shares are constant. One can show that a linear transformation of the widely used CES-preferences is indeed the most general form of additively separable homothetic preferences. Note that homotheticity (for additive preferences) requires $v'(0) = \infty$ as otherwise sufficiently poor agents do not buy an expensive variety, i.e. their expenditure share is zero, whereas the expenditure share of sufficiently rich agents is positive, which contradicts homotheticity.

Figure 2.2: Extensive margin of consumption



of varieties that are consumed in positive quantities - the extensive margin of consumption. An increase in per capita income lowers the marginal utility of income λ_n and thus increases the extensive margin of consumption - richer countries consume a broader set of varieties. A first order stochastic dominance shift in the price distribution increases the extensive margin of consumption as well - countries that are better integrated and have therefore lower prices will consume broader sets of varieties. Note finally that for $v'(0) \to \infty$ the extensive margin goes towards one and agents would not adjust their extensive margins with income.

In the Ricardian model, a country's per capita income depends on that country's technology - the better technology, the higher the wage rate and thus per capita income. In the model there are two channels of how an importing country n's technology affects the extensive margin of trade. The first channel is the standard supply side channel. A better technology implies better productivity draws for more varieties so that the share of varieties π_{nn} for which local producers offer the best prices rises. But this implies that the share of varieties that are imported, $(1 - \pi_{nn})$, and therewith the extensive margin of bilateral trade tends to fall. On the other hand the non-homothetic model exhibits a second channel. Better technology leads to higher wages and agents therefore extend their extensive margin of consumption, which tends to increase the extensive margin of trade. In the calibrated version of model it will turn out that the latter effect dominates so that the extensive margin of bilateral trade is positively correlated with per capita incomes. In the homothetic model on the other hand only the first effect is present (all countries' extensive margins of consumption are one) and the correlation between extensive margin of trade and importer income is unambiguously negative. Note also that in the non-homothetic model the decomposition of aggregate gdp into population size and per capita income matters - a rich, but small country has a high extensive margin of consumption and thus also tends to import broad sets of varieties, whereas the opposite is true for a poor, but large country although the two countries may have the same aggregate gdp.

Whereas the non-homothetic and the homothetic model can have opposing predictions for the extensive margin of bilateral trade, they exhibit the same pattern for the aggregate volumes. This feature will be very useful when calibrating the model and comparing its performance to the the homothetic model. Note also that with respect to aggregate volumes both models do not have separate roles for differences in per capita incomes that are induced by differing technologies.[11]

2.3 Quantifying the model

In this section I quantify the model to assess whether my theory is able to explain the behavior of the extensive margin of trade. I calibrate the model parameters using data on aggregate trade volumes and US consumer behavior. I then simulate the parametrized model and compare the behavior of its extensive margin of bilateral trade with the data.

2.3.1 Parametrization of the utility function

I have shown above that the effects discussed emerge for a broad class of sub-utility functions $v(x)$. The central property is a bounded marginal utility, $v'(x) < \infty$. To

[11] In the data richer countries tend to trade more. One potential explanation is brought forward by Waugh (2010) who argues that richer countries have systematically lower trade costs. I will capture this in the calibration by following Waugh (2010)'s approach to modeling trade costs.

quantify the model I need to choose a parametric form for $v(x)$. I will use the Stone-Geary form

$$v(x) = \log(\bar{x} + x),$$

where $\bar{x} \geq 0$, as the thus parametrized model nests the standard homothetic model with $\bar{x} = 0$.[12] The preference parameter $\bar{x}$ represents the degree of non-homotheticity. In the context of this chapter it is particularly important that it governs the marginal utility of starting to consume an additional variety, $v'(0) = 1/\bar{x}$. The closer the non-homotheticity parameter $\bar{x}$ gets to zero the larger the marginal utility of consuming new varieties and thus the weaker the demand side effects on the extensive margin of trade. For $\bar{x} = 0$ the marginal utility approaches infinity and agents find it optimal to consume all available varieties no matter how expensive they are.

In the robustness section I will show that the results remain unchanged for alternative preferences specifications with bounded marginal utility such as quadratic preferences and CARA preferences.

2.3.2 Calibration strategy

The theoretical model's bilateral trade pattern are characterized by two moments - the extensive margins and aggregate volumes. Volumes are governed by

$$X_{ni} = \pi_{ni} w_n L_n$$

and the extensive margins are

$$m_{ni} = \pi_{ni} M_n.$$

Labor market clearing $w_i L_i = \sum_{n=1}^{N} X_{ni}$ determines the equilibrium wage rates and the equilibrium extensive margins of consumption follow from the budget restriction (2.2.3). In the appendix I show that with Stone-Geary preferences the budget restriction can be

[12] For $\bar{x} = 0$ the preferences become CES preferences with an elasticity of substitution of one. Since the quantitative behavior of the homothetic model is independent of the elasticity of substitution (see Alvarez and Lucas (2007)) the results represent the general CES model.

written as

$$w_n = \bar{x}\left(\Phi_n\right)^{-\frac{1}{\theta}}\left(M_n\left(-\log\left(1-M_n\right)\right)^{\frac{1}{\theta}} - \gamma\left(\frac{1}{\theta}+1; -\log\left(1-M_n\right)\right)\right), \qquad (2.3.1)$$

where $\gamma\left(z,\bar{t}\right) = \int_0^{\bar{t}} t^{z-1}e^{-t}dt$ is the incomplete Gamma function.

The model parameters are the countries technologies' T_i and populations L_i, the bilateral trade costs d_{ni}, the non-homotheticity parameter $\bar{x}$, and the trade elasticity θ. Whereas the populations can be taken from the data, I need to calibrate the remaining parameters. In the following I describe how I calibrate these parameters. The data used for the calibration is discussed en passant with a more complete description in the appendix. I start with the calibration strategy for the non-homotheticity parameter as this is the most novel part of the model. I then discuss the trade elasticity, trade costs, and technologies in turn.

2.3.2.1 Non-homotheticity parameter

To calibrate the non-homotheticity parameter I use data of the US Consumer Expenditure Survey (CEX) of the year 2003. The advantage of using this source is its independence from the trade data. Based on this database I construct the expenditures of around 3000 households for 107 different categories of tradable goods such as "Encyclopedia and other sets of reference books", "Wigs, hairpieces, or toupees ", and "Winter sports equipment". Details can be found in the appendix. Counting the categories with positive expenditure gives me a measure for the extensive margin of consumption of a household. Table 2.2 reports the elasticity of this measure of the extensive margin with respect to total expenditures controlling for demographic variables such as household size, age of the reference person, and geography, i.e. rural/urban and region (Northeast, Midwest, South, West). Table 2.2 also reports the elasticities for a more liberal expenditure classification that comprises 186 categories.[13] Clearly, the positive elasticity is robust across specifications lying between 0.4 and 0.5. For the calibration I will target the elasticity associated with

[13]The main difference lies in the treatment of housing- and gender-related categories. The conservative classification excludes these categories, whereas the liberal classification aggregates over categories that represent the same item but differentiate by renter and owner or women, men, girls, and boys.

Table 2.2: Dependent variable - extensive margin of consumption

specification	I		II		III		IV	
classification	cons.	liberal	cons.	liberal	cons.	liberal	cons.	liberal
expenditures	0.48***	0.52***	0.43***	0.48***	0.42***	0.46***	0.41***	0.46***
age dummies	no	no	yes	yes	yes	yes	yes	yes
HH members	no	no	no	no	yes	yes	yes	yes
geography	no	no	no	no	no	no	yes	yes
N	2981	2982	2981	2982	2846	2847	2846	2847
R^2	0.33	0.39	0.35	0.42	0.36	0.43	0.38	0.44

the conservative classification and the specification including all controls, 0.41.

To understand the details of the calibration, first note that for trade volumes only the relative technologies matter, which implies that we cannot identify the absolute level of the technologies using aggregate trade volumes. In the budget constraint (2.3.1) on the other hand the absolute level of technologies is relevant since it determines the level of Φ_n. Moreover note that scaling all technologies by a constant has the same effect as scaling the non-homotheticity parameter. Therefore I can normalize either the level of technologies or the preference parameter. It is convenient to choose to normalize the level of the technologies such that the US-aggregator, Φ_{US}, equals one. Then the budget constraint of a US-agent h with income w_h is

$$w_{US,h} = \bar{x}\left(M_{US,h}\left(-\log\left(1-M_{US,h}\right)\right)^{\frac{1}{\theta}} - \gamma\left(\frac{1}{\theta}+1; -\log\left(1-M_{US,h}\right)\right)\right).$$

Setting $\theta = 4.5$ (see next section) and for a given non-homotheticity parameter $\overline{x}$ I can feed all the CEX households' incomes into the budget constraint and calculate corresponding extensive margins of consumption. I then choose the preference parameter such that the resulting elasticity of the extensive margin of consumption matches the empirical CEX elasticity.[14,15]

2.3.2.2 Trade elasticity

For the trade elasticity I take the value estimated by Simonovska and Waugh (2010), $\theta = 4.5$. In general, one cannot separately identify the trade elasticity and the level of trade costs by estimating a gravity equation - the trade elasticity may be high and trade costs low or conversely, the elasticity low and trade costs high. To tackle this problem

[14]The resulting value is $\overline{x} = 3.14$. In contrast to for example the elasticity of substitution of CES-preferences this parameter does not have a standalone interpretation (beyond the fact that it is not zero) since measures such as the demand elasticity or elasticity of substitution change with income and prices. Therefore $\overline{x}$ is only meaningful when income and price distribution are known or as in the case here, when a model giving rise to income and prices is parametrically specified.

[15]On a first sight the fact that I use within country inequality to calibrate a model where countries are populated by representative agents may seem surprising. I address this objection in the robustness section, where I consider the potential role of within-country inequality. Also I refer to the well-established practice in the macro literature using microeconomically estimated elasticities to calibrate macro models populated by representative agents.

EK argue that one can use disagregated price data from the Worldbank's International Comparison Project (ICP) and take the maximal (or second highest) within good price difference as an estimate for bilateral trade costs. As the resulting value for trade costs has been obtained independently from trade volumes one then can solve for the trade elasticity that is implied by a gravity type regression. Simonovska and Waugh (2010) extend this approach. They provide a more elaborate estimation strategy that controls for an aggregation bias arising from the fact that due to the small number of goods categories in the ICP (around 80) it is very unlikely that the highest price difference represents actually the trade costs. They also use a broader set of countries (123) and are thus able to check if the trade elasticity systematically varies with development level, which they find is not the case. The structural framework for their estimation is the EK model. Since my model behaves similar to the EK model with respect to volumes and prices I can directly adapt the Simonovska and Waugh (2010) baseline estimate of $\theta = 4.5$.

2.3.2.3 Trade costs

I calibrate the trade costs using aggregate bilateral trade volumes of the year 2003. In particular I follow Waugh (2010) in modeling unobserved trade costs as a function of observed proxies and an exporter fixed effect

$$d_{ni} = \exp\left\{\delta_k + b + l + ex_i + \varepsilon_{ni}\right\},$$

where I suppressed the associated dummy variables for expositional simplicity. δ_k ($k = 1, ..., 6$) is the effect of the bilateral distance between countries i and n lying in in the kth distance interval. The intervals are (in miles): $[0, 375)$, $[375, 750)$, $[750, 1500)$, $[1500, 3000)$, $[3000, 6000)$, and $[6000, \infty)$. b is the effect of sharing a border, and l the effect of having the same language. ex_i is an exporter fixed effect that allows for asymmetry in bilateral trade costs and ε_{ni} captures all other trade barriers and is assumed to be orthogonal to the exporter fixed effects, distance, border, language, and membership in the same trade agreement.

Normalizing the volume of the bilateral trade flow from i to n (equation (2.2.8)) with

Table 2.3: Estimated trade costs

estimated coefficients		
variable	coefficient	%-effect
$[375, 750)$	-0.53^{***}	13%
$[750, 1500)$	-1.52^{***}	40%
$[1500, 3000)$	-1.97^{***}	55%
$[3000, 6000)$	-2.84^{***}	88%
$[6000, \infty)$	-3.33^{***}	110%
shared border	0.77^{***}	-16%
same language	0.82^{***}	-17%
estimated trade costs (d_{ni})		
countries	mean	median
OECD	2.01	1.89
non-OECD	4.27	3.53
all countries	3.91	3.14

the importer's home sales X_{nn} yields

$$\frac{X_{ni}}{X_{nn}} = (d_{ni})^{-\theta} \frac{S_i}{S_n}, \tag{2.3.2}$$

where $S_i = T_i (w_i)^{-\theta}$ is a country fixed effect. The value of the bilateral trade flow X_{ni} is observed, whereas - in the context of the model - X_{nn} is simply a country's aggregate gdp less its total imports.[16] Imposing above trade cost function yields a Gravity-type equation that I estimate using the Poisson pseudo-maximum likelihood estimator proposed by Silva and Tenreyro (2006). Table 2.3 reports the resulting estimates for the trade cost parameters together with the associated effects on trade costs and some summary statistics on the estimated trade costs.

[16]It is important to mention two potential caveats related to the way the model is mapped to the data. First, I use aggregate trade volume, which includes also non-consumption goods such as intermediates. Second, whereas trade is measured in gross values gdp is measured as value added, which again in the context of intermediates may be of importance. I address both caveats in the robustness section where I extend the model to allow for intermediates. It turns out that the main results remain basically the same. The reason for this may be that the share of consumption goods in trade flows is unrelated to per capita gdp and aggregate gdp, so that no systematic bias emerges.

The average and median trade costs among OECD countries are 2.01 and 1.89 respectively, which is slightly higher than often cited 1.7 suggested by Anderson and Van Wincoop (2004) and very much in line with Waugh (2010). Consistent with the findings in the literature trade costs among non-OECD countries are considerably higher.

2.3.2.4 Technologies

The most straightforward approach to recovering technologies is to follow Fieler (2010) and take per capita incomes[17] as a proxy for wages - indeed in the model wages and per capita incomes coincide. Using the estimates for the country fixed effects, $\hat{S}_i$, one then can directly solve for the implied technologies, $\hat{T}_i = \hat{S}_i (w_i)^\theta$. An alternative approach disregards the country fixed effects and uses the market clearing conditions (2.2.9) to recover the technologies: Plugging the per capita incomes, the estimated trade costs and the trade elasticity into the market clearing conditions allows me to solve for the unique set of technologies for which all markets clear. Figure 2.3 plots the expected productivity draw in a country, $E_i [z] = T_i^{1/\theta}$, against its per capita income. Clearly the two approaches yield very similar technologies. Moreover, as it is to expect there is a high correlation between estimated technology and observed incomes. However, note that the correlation is not perfect as different geographic locations imply that countries with the same technology face differing levels of demand and thus have different equilibrium incomes. For the remainder of the chapter I use the technologies calibrated using the market clearing conditions.[18]

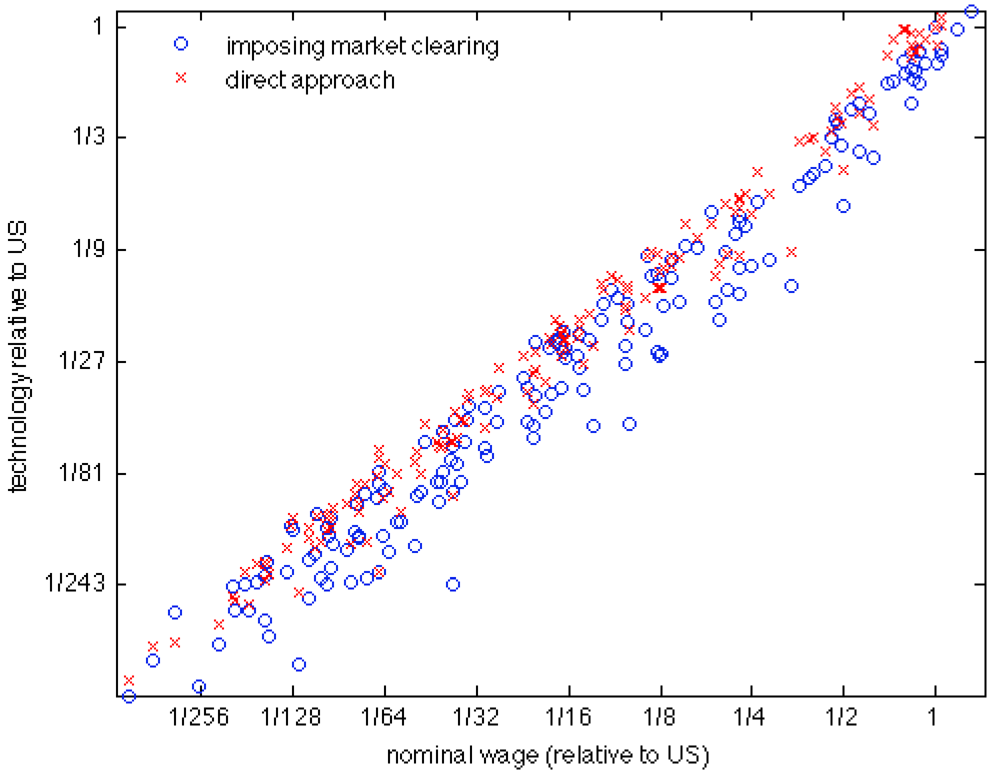
2.3.3 Calibration results

Given the calibrated parameters I now can simulate the model and compare the behavior of its extensive margin to the data. Remember that with respect to volumes the non-homothetic model behaves similar to the homothetic model. Hence, as we used volumes to calibrate technologies and trade costs, these calibrated values also apply to the homothetic

[17] In the context of the model using nominal incomes is appropriate as deviations from PPP are endogenous in the EK framework.

[18] The results for the alternative technologies are very similar with differences in the outcomes typically lying within 1-2%.

Figure 2.3: Calibrated technologies vs. observed incomes



model. I.e. we obtain the homothetic model's predictions simply by setting the non-homotheticity parameter to zero, $\overline{x} = 0$.

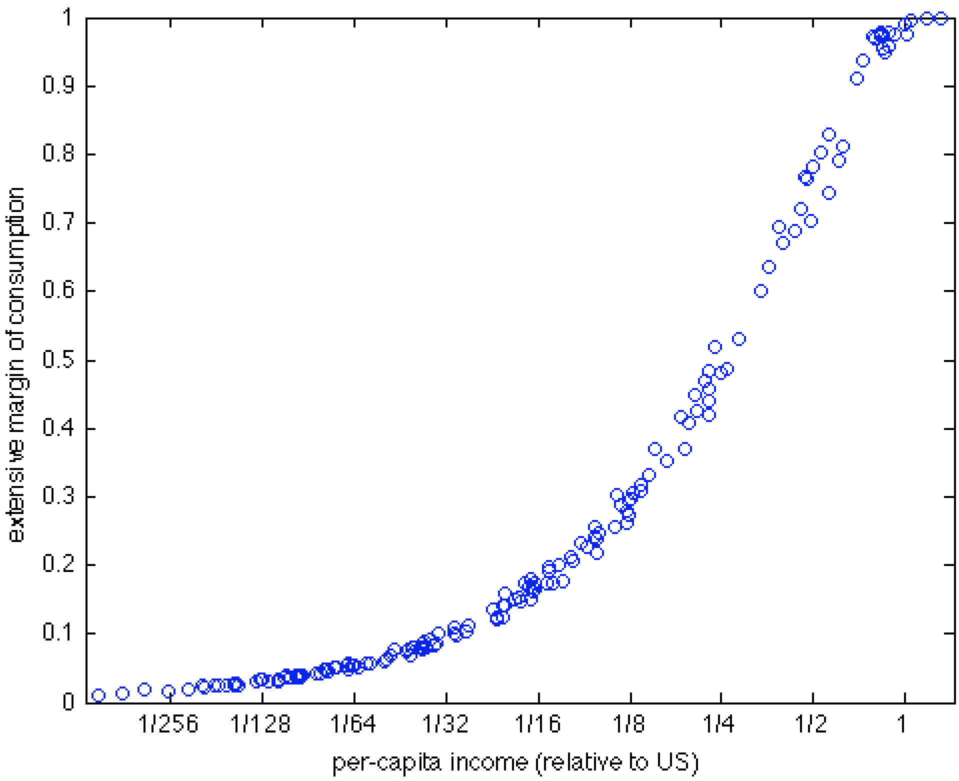
The motivating fact of this chapter is the positive correlations between the extensive margin of bilateral trade and the per capita incomes of the trading partners. Table 2.4 reports the income elasticities that follow from repeating the regressions cited in the introduction using the model data.

For the exporter income elasticity both models yield the same elasticity. Moreover the elasticity is reasonably close to what is observed in the data. For the importer income

Table 2.4: : Income elasticities of the extensive margin of bilateral trade

	elasticities in data		elasticities in models	
	all vars	C only	non-homothetic	homothetic
exporter income	0.83	0.65	0.86	0.86
importer income	0.49	0.46	0.63	−0.12

Figure 2.4: Calibrated extensive margins of consumption vs. observed incomes



elasticity on the other hand only the non-homothetic model's sign is consistent with the data. With 0.63 the non-homothetic model's elasticity is somewhat higher than the data's income elasticity of around 0.5, but still reasonably close. The homothetic model on the other hand predicts a negative importer income elasticity of -0.12. The reason for this counterfactual prediction is its negligence of the extensive margin of consumption. So that only the negative effect of a technologically advanced country producing more varieties locally is present. In the non-homothetic model this negative effect is dominated by a positive effect coming from the demand side - the expanding extensive margin of consumption. Figure 2.4 plots the calibrated extensive margin of consumption against per capita income. Note that the relation is not perfect. The reason for that are differences in the remoteness. Spain and New Zealand for example had the same nominal per capita income in 2003, however Spain's calibrated extensive margin of consumption is almost 10% higher than New Zealand's as Spain's geographic location is much more favorable. This means that prices tend to be lower in Spain so that its real income is higher and agents find it optimal to consume a broader set of varieties.

2.3.4 The quantitative importance of the demand side

In this section I perform two counterfactual experiments. The goal of these exercises is to demonstrate that accounting for demand side effects is quantitatively important when thinking about the reaction of the extensive margins of trade to changes in the economic environment. In each case I start with the world economy as calibrated in the previous section and compare the counterfactual outcome to the initial situation.

2.3.4.1 The rise of China and India

One of the most important trends in the global economy is the rise of China and India. These two countries experienced spectacular growth rates in the recent years - according to the World Development Indicators (Worldbank, 2010) China's per capita income almost doubled (95%) relative to the world per capita income between 1993 and 2003, important India's per capita income grew by 31% relative to world per capita income. In this experiment I consider the calibrated 2003 world economy and ask how trade pattern would change if China's and India's technologies improve such that their incomes rose again by the same magnitudes relative to the world income.

The homothetic model predicts that because China and India's technologies improve these two countries become competitive in more varieties. Therefore these countries export broader sets of varieties (the median increase is 76% for China and 17% for India). At the same time the better technology implies also that these countries import a narrower set of varieties. In important China is predicted to source 54% more varieties locally, whereas India's home share extends by 2%. This translates into median decreases in the extensive margin of bilateral import flows of 15% and 14% for China and India respectively.

These predictions turn when one allows for non-homothetic consumer behavior. In the non-homothetic model China and India extend their extensive margin of consumption as their incomes increase (82% in China and 34% in India), so that the measures of imported varieties actually increase by 53% and 33%. This translates into median increases in the

Table 2.5: : Summary statistics for changes in trade costs

	10%-reduction		25%-reduction		50%-reduction	
	new	EK	new	EK	new	EK
mean	9%	2%	27%	5%	103%	37%
median	8%	0%	22%	−1%	85%	18%
top10%	22%	16%	65%	43%	207%	118%
bottom10%	−2%	−11%	−3%	−25%	16%	−31%
% negative	15%	49%	15%	51%	6%	35%

extensive margins of bilateral import flows of 55% for China and 14% for India.

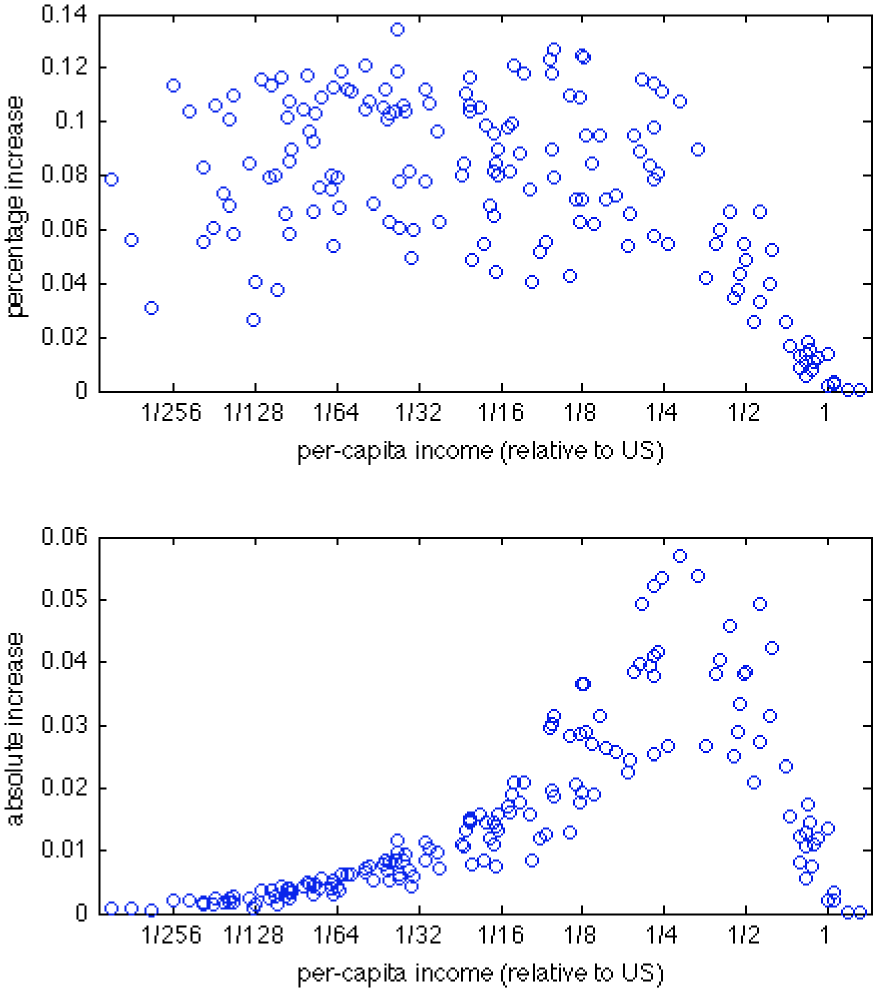
2.3.4.2 Changes in trade costs

In a second experiment I consider the effect of reductions in trade costs. Lower trade costs affect the extensive margin of trade trough two channels. The first channel is the standard supply side channel - lower trade costs imply that trade becomes worthwhile for more varieties, i.e. the extensive margin of trade will expand. However, there is a second channel operating trough the demand side - lower trade costs lead to lower prices[19] which increases real incomes. With higher incomes agents will find it optimal to consume broader sets of varieties, which in turn will tend to increase the extensive margins of trade. In order to assess the relative importance of these two channels I take again the calibrated 2003 world economy and uniformly decrease trade costs by 10, 25, and 50 percent.

From Table 2.5 reporting summary statistics on the percentage changes in the extensive margins of bilateral trade the starkly differing predictions of the homothetic and the non-homothetic model become apparent. The homothetic model for example predicts that for a 25%-reduction in trade costs more than halve of country-pairs actually experience reductions in the bilateral extensive margins. This is because low-tech supplier countries were competitive in nearby markets in the initial situation with high trade costs, but lower trade costs imply that they are now dominated by countries with better technologies such

[19] Above I chose the US wage as the numéraire. Therefore I describe the adjustment via lower prices. Alternatively with some goods price as the numéraire the corresponding adjustment would be described by lower trade costs increasing productivity and therewith wages.

Figure 2.5: Absolute and relative changes in the extensive margin of consumption



that their export margins tend to fall. In the non-homothetic model this supply-side effect is attenuated by the demand-side effect of a rising extensive margin of consumption, the absolute and relative changes in which are plotted in Figure 2.5 against per capita incomes. Whereas poor countries experience the highest relative changes, middle income countries have the highest absolute changes. Relative to the supply side effect these changes are large such that for example the number of country pairs experiencing falling extensive margins goes back to 15% and the predicted median change is an increase of 22% instead of a decrease of 1% in the homothetic model. These contrasting predictions demonstrate that it is indeed important to account for demand side effects when thinking about the extensive margin of bilateral trade.

2.4 How general is the proposed channel?

I have presented a model of international trade where agents adjust their extensive margin of consumption with income, which has quantitatively important effects for the extensive margin of bilateral trade. In order to highlight this novel demand side channel, I kept the supply side very simple by adapting a perfectly competitive Ricardian framework. I found that when allowing for non-homothetic consumer behavior the EK model is not only able to capture the pattern of aggregate trade volumes, but also the behavior of the extensive margin of trade. The more general message is that the extensive margin of trade may be driven by a considerable amount trough differences in demand pattern across countries. In the following I discuss how this channel generalizes to richer models and why accounting for the demand side is potentially important.

A richer model of international trade would model the firm explicitly by allowing for market power as in Krugman (1980) and Melitz (2003). Fixed market entry costs implied that not all firms find it optimal to enter all markets, which gives rise to an extensive margin of trade. In particular, for a given level of entry costs, it is more attractive to enter bigger markets since the contribution margin in these markets is larger. With homothetic preferences the notion of a "big market" is purely driven by aggregate gdp - due to constant expenditure shares it does not matter if we have a large and poor population or a small and rich population. With non-homothetic preferences however the decomposition of aggregate gdp becomes relevant as poor agents adjust their expenditure shares with income. In the model developed above this is particularly apparent when the expenditure share goes from zero (when the non-negativity constraint is binding) to some positive share - the thus emerging extensive margin of consumption then drives the extensive margin of trade. In a more general setting with market entry costs it is not only the bounded marginal utility that is relevant but also poor agents relatively concentrating their expenditures on cheap goods. A small, but rich market may therefore be sufficiently "big", whereas demand in the poor, but populous market (with the same aggregate gdp) may be too low for the operating profits to cover market entry costs - accordingly the small, but rich market's extensive margins of import flows will tend to be higher than the ones of the large, but poor market. Clearly, in such a framework it would not only be average income, but also the entire shape of the income distribution that is relevant for a firm's entry decision. Ignoring non-homothetic demand thus leads a researcher to attribute differences in the extensive margins of import flows entirely to differences in market entry costs, whereas a considerable part of it may be driven by differences in average income and the income distribution.

2.5 Robustness and extensions

2.5.1 Extending the model to trade in intermediates

The model I developed above is one of consumption goods only. I chose to abstract from intermediate goods to keep the model as simple as possible. In this section I outline a model with intermediate goods and final goods - both tradable. The purpose of this extension is twofold: First, I use the extended model to assess if abstracting from intermediate goods introduces a significant bias in the quantification. Second, to compute the left hand side of equation (2.3.2) I used trade and gdp data. However, many papers using the EK framework are models of trade in intermediates, in the context of which gross manufacturing output is used instead of gdp data. With the intermediate extension I will need to use gross manufacturing output and thus one can assess by how much the results were driven by these different ways of computing the normalized trade flows.

In the extended model there are two industries, $\iota = I, F$. I produces tradable intermediate goods and F produces tradable final goods.[20] Both industries bundle labor and a CES-aggregate of intermediates using a Cobb-Douglas production technology with labor share β. Cost minimization implies that the price of at which country i can offer a industry ι-variety j_ι in market n is

$$p_{ni}\left(j_\iota\right) = \frac{d_{ni}}{z_i\left(j_\iota\right)} w_i^\beta P_i^{1-\beta},$$

[20]Note that in EK and follow up papers it is usually assumed that final goods are non-traded.

where $P_i = \left(\int_0^1 p\left(j_I\right)^{1-\sigma} dj_I\right)^{1/(1-\sigma)}$ is the CES price index.[21] I omitted a constant depending on the labor share β. For expositional simplicity I will omit constants in the following formulas, which corresponds to a particular normalization of technologies. Assuming Fréchet distributed productivities with similar parameters across industries yields a gravity-like expression that looks in its reduced form similar to the one derived above

$$\frac{X_{ni}}{X_{nn}} = \left(d_{ni}\right)^{-\theta} \frac{S_i}{S_n}.$$

However, there are two crucial differences: First, total demand, X_n, is now the total intermediate absorption, X_n^I, plus total final goods demand, X_n^F. Consequently, following EK the home supply now has to be imputed by subtracting a country's total manufacturing exports from its gross manufacturing output, which I mostly get from UNIDO (2003) (details in the appendix). Data constraints reduce the sample to 71 countries. Second the country fixed effects include now the countries' intermediate price indices, $S_i = T_i \left(w_i^{\beta} P_i^{1-\beta}\right)^{-\theta}$. Note that in the simple model without intermediates the price indices P_i were absorbed into the calibrated technologies and wages entered with an exponent of one, which implies that the model tended to overstate the dispersion in technologies (standard deviation in log of technologies is 2.7 with intermediates[22] vs. 7.5 without intermediates). Explicitly considering intermediates may particularly matter for counterfactual experiments changing the trade costs, as this implies potentially large changes in the intermediate price indices.

Using the same procedure as in the main text (but a different measure for X_{nn}) I can estimate the trade costs and the country fixed effects. To recover technologies there are again two approaches: The more direct approach uses the estimated country fixed effects, $\widehat{S}_i$ and trade costs, $\hat{d}_{ni}$, to compute the implied price indices, $\hat{P}_n = \left(\sum_{i=1}^N T_i \left(w_i^{\beta} P_i^{1-\beta} d_{ni}\right)^{-\theta}\right)^{-1/\theta} = \left(\sum_{i=1}^N \hat{S}_i \left(\widehat{d}_{ni}\right)^{-\theta}\right)^{-1/\theta}$ and then use these price indices together with the per capita incomes, w_i, and calibrated values for β and θ to solve

[21] I assume that trade costs and labor share are the same across the two industries.

[22] The standard deviation of $\log\left(T_i P_i^{-(1-\beta)\theta}\right)$, i.e. the technologies with absorbed intermediate price index is 2.9.

for the implied technologies, $\widehat{T}_i = \widehat{S}_i \left(w_i^{\beta} \widehat{P}_i^{1-\beta} \right)^{\theta}$. Alternatively, one can combine the estimated trade costs and the per capita incomes and solve directly for the unique set of technologies for which all markets clear.[23] The correlation (in logs) between the thus calibrated technologies is very high at 0.96. I use the technologies based on imposing market clearing.

The price distribution of final goods in country n is

$$G_n(p) = 1 - \exp\left\{ -p^{\theta} \sum_{i=1}^{N} T_i \left(w_i^{\beta} P_i^{1-\beta} d_{ni} \right)^{-\theta} \right\}.$$

Normalizing technologies such that $\sum_{i=1}^{N} T_i \left(w_i^{\beta} P_i^{1-\beta} d_{USi} \right)^{-\theta} = 1$ I can use the same value for the non-homotheticity parameter as above. Simulating the thus calibrated model yields an importer income elasticity of the extensive margin of bilateral trade of 0.58 (the corresponding elasticity in the model without intermediates is 0.57 whereas the empirical elasticity is 0.50 in the restricted sample of 71 countries). Considering the counterfactual experiments, the model with intermediates generally features even stronger differences between the predictions of the homothetic and the non-homothetic model. This is because the intermediate price index reacts to changes in trade costs or technologies respectively, which amplifies the reaction of the price distribution of final goods and thus agents tend to adjust their extensive margins of consumption more strongly.

2.5.2 Inequality

Up to now I abstracted from within-country inequality and had each country populated by representative agents. Although most of the global inequality is indeed explained by differences in average incomes, within-country inequality is a potentially important determinant for the extensive margin of trade - consider two countries with the same average income, but one with a wider range of the income distribution. My model would predict that the country with the richer agents has a broader extensive margin of consumption

[23] Specifically, I take an initial guess for the technology vector, compute the implied price indices, and use these together with the initial guess to compute π_{ni} and then the countries' balances of payments. I adjust the technology guess using a tâtonnement-like algorithm until all markets clear.

and thus tends to import more varieties.[24]

Taking my model literally implies that if each country features one very rich agents all countries extensive margins of consumption were one and all the demand side effect disappeared. I.e. this model's extensive margin is very sensitive to the upper tail of the income distribution. The main theoretical reason why this may not be the case is the presence of fixed market entry costs (beachhead costs). Incorporating these into my model would require departures from the competitive setting to allow for positive markups that can be used to cover the beachhead costs, which would disproportionally complicate the model.[25]

In order to nonetheless get a feeling for the potential importance of the within-country income distribution I propose a simple exercise that allows me to stay within the Ricardian framework. In particular I choose to use the average income in the top quintile to compute the extensive margin of consumption: Remember that conditional on entering market n the price distribution is the same across supplier countries. Therefore agents will have the same average expenditures across countries, which implies that π_{ni} is the expenditure share of each agent independent of his total expenditures. Consequently the aggregate value of the flow from i to n is still $X_{ni} = \pi_{ni} w_n L_n$. I.e. aggregate volumes do not depend on the income distribution so that we can use the same calibration strategy as above. The non-homotheticity parameter $\overline{x}$ calibrated using the CEX data remains unchanged. However, I acknowledge the presence of within-country inequality by using the average income among the top quintile in the budget constraint (2.3.1) instead of per capita income. Taking the model literally this amounts to allowing for a general income

[24]Indeed, when repeating the regressions cited in the introduction including the importer's top-quintile of the income distribution I get positive coefficients for the top-quintile. The elasticity considering consumption goods only is 0.23 and significant at the 1% level, whereas the elasticity for all types of goods is lower at 0.15 and significant only at the 10% level.

[25]With non-homothetic preferences markups become endogenous. With a representative agent the model still preserves some tractability (see Simonovska (2010)) as per market there is one cutoff productivity above which firms enter this market and below which firms abstain from entering. However, if one introduces within-country inequality firms not only decide whether to enter a market or not, but also whom to supply in this market. I.e. the equilibrium is characterized by a correspondence between productivity and income of the agent that just consumes this firms variety at the optimal quantity of zero. Unfortunately, there is no simple expression for this correspondence. Since each country has its own productivity and income distributions, there are N^2 such correspondences, which is the reason why the model loses all its tractability.

distribution that is bounded by the average income in the top quintile. In a more general sense I hope to learn from this exercise how the results change when trying to account for differences at the top of countries' income distributions.

I use quintile data from UNU-WIDER (2008) that are described in detail in the appendix. As the quintiles are not available for the full sample I consider a smaller sample of 112 countries. I reestimate the model parameters for this smaller sample of countries.[26] Accounting for within-country inequality by using average incomes in the top quintiles in the budget constraint yields a lower importer income elasticity of 0.52 (vs. 0.46 in the data).

2.5.3 Alternative utility functions

In the theory part I worked with a general utility function with the crucial feature of a bounded marginal utility. For the quantification I then had to assume some particular functional form for the utility function (Stone-Geary). This section considers two alternative utility functions with bounded marginal utility and shows that the calibration results are robust to the particular functional form. I only consider one-parameter utility functions as my calibration strategy for the demand side targets only one moment.

In particular, I consider quadratic utility

$$v^{quadr}(x) = x - \frac{1}{2}a^{quadr}x^2,$$

which is popular for its linear demand functions and constant absolute risk aversion utility (CARA)

$$v^{cara}(x) = -\exp\{-a^{cara}x\}.$$

A reader might note that often these utility functions are written with three parameters.[27] However, in the context of a static trade model utility functions have a pure ordinal purpose so that all monotonic transformations of the utility function, $U = \int v(x(j))\,dj$,

[26]For this smaller sample of countries the calibrated importer income elasticity for the representative agent model barely changes (0.62 instead of 0.63).

[27]$v^{cara}(x) = B^{quadr} - C^{quadr}\exp\left\{-a^{quadr}x\right\}$ and $v^{quadr}(x) = B^{cara} + C^{cara}x - 1/2a^{cara}x^2$.

yield the same economic behavior.[28] The one-parameter versions above are simply linear transformations of the often seen three parameter versions.

As aggregate trade volumes do not depend on the particular functional form of the utility function the supply side parameters calibrated above (trade elasticity, trade costs, technologies) still apply, i.e. I only need to recalibrate the demand side parameter. In the appendix I derive the analog to equation (2.3.1) governing the extensive margin of consumption for a given income and price distribution. Using these equations I calibrate the new utility parameters by targeting US consumers' income elasticity of the extensive margin consumption.[29] I then simulate the calibrated models and calculate the income elasticities of the extensive margin. The resulting exporter income elasticities are the same as above as they do not depend on the demand side of the model. The importer income elasticities on the other hand crucially depend on the demand side as demonstrated above when comparing the homothetic model with the non-homothetic model. However, when considering the alternative non-homothetic utility functions the importer income elasticities change only very little (0.618 for CARA and 0.623 for quadratic preferences instead of 0.614 for Stone-Geary). Similarly, the quantitative effects in the counterfactual experiments do not significantly change. These results demonstrate that whereas accounting for non-homotheticity when thinking about the extensive margin of trade is very important, the quantitative behavior does not seem to depend very much on the particular functional form.

2.6 Conclusions

In this chapter I discuss the importing country's demand structure as a determinant of the extensive margin of bilateral trade. I draw on the evidence of microeconomic studies that show that richer agents consume more variety. Allowing for such an extensive margin of consumption in an otherwise standard Ricardian trade model offers an explanation for the positive correlation between the extensive margin of bilateral trade and the importers

[28] It is important to note, that the transformation is applied to the aggregate utility function, U, and not directly to the sub-utility function.

[29] The resulting parameters are $a^{quadr} = 3.59$ and $a^{cara} = 0.33$.

per capita income. I quantify the model using data on aggregate trade volumes, and US consumer behavior. I find that the calibrated model's extensive margin of trade behaves similar to what we observe in the data. Two counterfactual experiments demonstrate that this novel demand side channel is quantitatively important.

I mentioned in the introduction that other authors have used non-homothetic preferences to discuss different aspects of the pattern of international trade such as aggregate volumes and quality. A potentially fruitful avenue for future research is a model where these two aspects and the extensive margin of trade could be analyzed simultaneously. On the demand side, such a framework would feature agents that adjust their consumption decision at the intensive, the extensive, and the quality margin. On the supply side variations in countries abilities to produce quality goods would introduce comparative advantages. Trade pattern – volumes, extensive margin, and quality – could then be analyzed as the result of interactions of the exporter country's production structure and the importer country's demand pattern.

2.A Appendix

2.A.1 Derivation of the country specific price distribution $G_n(p)$

Using the productivity distribution and the pricing equation (2.2.4) the probability of country i supplying a particular variety j at a price lower than p in market n can be written as

$$G_{ni}(p) = \Pr\left[P_{ni} \leq p\right] = \Pr\left[\frac{w_i d_{ni}}{Z_i(j)} \leq p\right] = \Pr\left[\frac{w_i d_{ni}}{p} \leq Z_i(j)\right]$$
$$= 1 - \exp\left\{-T_i\left(w_i d_{ni}\right)^{-\theta} p^{\theta}\right\}.$$

The probability that the lowest price on offer in market n is below p is the complement to the probability that all offered prices lie above p

$$G_n(p) = \Pr\left[\min\left\{P_{ni}(j)\right\}_{i=1}^{N} \leq p\right] = 1 - \Pr\left[\min\left\{P_{ni}(j)\right\}_{i=1}^{N} > p\right].$$

As the productivity draws are iid across countries above probability is simply the product of the individual probabilities, which yields the price distribution from the main text

$$G_n(p) = 1 - \sum_{i=1}^{N} \Pr\left[P_{ni}(j) > p\right] = 1 - \exp\left\{-p^{\theta} \sum_{i=1}^{N} T_i\left(w_i d_{ni}\right)^{-\theta}\right\}.$$

2.A.2 Derivation of the trade share π_{ni}

The probability that country i is the cheapest supplier for a variety j in market n is given by

$$\pi_{ni}(j) = \Pr\left[P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] = \int_0^{\infty} \Pr\left[p < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] dG_{ni}(p).$$

Again one can write the distribution of the minimum price as the product of the individual distributions

$$\int_0^\infty \Pr\left[p < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] dG_{ni}(p) = \int_0^\infty \prod_{k\neq i} \Pr\left[p < P_{nk}(j)\right] dG_{ni}(p)$$
$$= \int_0^\infty \prod_{k\neq i} G_{nk}(p)\, dG_{ni}(p).$$

Inserting for the price distributions yields

$$\pi_{ni}(j) = \int_0^\infty \prod_{k\neq i} G_{nk}(p)\, dG_{ni}(p) = \frac{T_i (w_i d_{ni})^{-\theta}}{\sum_{k=1}^N T_k (w_k d_{nk})^{-\theta}}.$$

Note that this probability does not depend on the index j so that it also represents the shares of varieties for which country i is the cheapest supplier in n

$$\pi_{ni}(j) = \pi_{ni} = \frac{T_i (w_i d_{ni})^{-\theta}}{\Phi_n}.$$

2.A.3 Conditional on entry price distributions are the same across sources

The distribution of prices from country i in market n conditional on being the cheapest supplier is

$$\Pr\left[P_{ni}(j) \leq p \middle| P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] = \frac{\Pr\left[P_{ni}(j) \leq p, P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right]}{\Pr\left[P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right]}.$$

The denominator is π_{ni}. The nominator can be written as

$$\Pr\left[P_{ni}(j) \leq p, P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] = \int_0^p \Pr\left[P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] dG_{ni}(p).$$

Similar steps as above yield

$$\Pr\left[P_{ni}(j) \leq p, P_{ni}(j) < \min\left\{P_{nk}(j)\right\}_{k\neq i}\right] = \pi_{ni} G_n(p).$$

Reinserting this into the initial expression completes the proof

$$\Pr\left[P_{ni}(j) \leq p | P_{ni}(j) < \min\{P_{nk}(j)\}_{k\neq i}\right] = G_n(p) = \Pr\left[\min\{P_{nk}(j)\}_{i=1}^N \leq p\right].$$

2.A.4 Derivation of the budget constraint for Stone-Geary preferences

First note that with Stone-Geary utility the first order conditions (2.2.1) become

$$\begin{aligned} \frac{1}{x(j)+\bar{x}} &= \lambda p(j) \quad \text{for } x(j) > 0 \\ \frac{1}{\bar{x}} &< \lambda p(j) \quad \text{for } x(j) = 0. \end{aligned}$$

Using these first order conditions I can solve for the price of the marginal variety

$$p(M) = \frac{v'(0)}{\lambda} = \frac{1}{\bar{x}\lambda}$$

and for the inverse of the marginal utility of income respectively

$$\frac{1}{\lambda} = \bar{x}p(M).$$

Optimal expenditures for varieties $j < M$ are

$$p(j)x(j) = \frac{1}{\lambda} - \bar{x}p(j) = \bar{x}(p(M) - p(j)).$$

Inserting this into a country n agent's budget restriction (2.2.3) yields

$$w_n = \bar{x}\left(p(M_n)M_n - \int_0^{p(M)} p dG_n(p)\right).$$

Using the country specific price distribution $G_n(p)$ one can write

$$p(M_n) = G_n^{-1}(M_n) = \left(-\frac{\log(1-M_n)}{\Phi_n}\right)^{\frac{1}{\theta}}$$

and

$$dG_n(p) = \theta p^{\theta-1}\Phi_n \exp\left\{-p^\theta \Phi_n\right\} dp.$$

Substituting this into the budget contraint yields

$$w_n = \bar{x}\left(\left(-\frac{\log(1-M_n)}{\Phi_n}\right)^{\frac{1}{\theta}} M_n - \int_0^{p(M)} p\theta p^{\theta-1}\Phi_n \exp\left\{-p^\theta\Phi_n\right\} dp\right).$$

Changing variables in the integral, $t = p^\theta \Phi_n$,

$$w_n = \bar{x}\left(\left(-\frac{\log(1-M_n)}{\Phi_n}\right)^{\frac{1}{\theta}} M_n - \int_0^{p(M_n)^\theta \Phi_n} \left(\frac{t}{\Phi_n}\right)^{\frac{1}{\theta}} \exp\{-t\}\, dt\right),$$

where the integral equals the incomplete Gamma function so that we can write

$$w_n = \bar{x}\left(\left(-\frac{\log(1-M_n)}{\Phi_n}\right)^{\frac{1}{\theta}} M_n - \left(\frac{1}{\Phi_n}\right)^{\frac{1}{\theta}} \gamma\left(\frac{1}{\theta}+1, p(M_n)^\theta \Phi_n\right)\right).$$

Substituting for the price of the marginal variety and rearranging leads finally to the expression of the main text.

2.A.5 Deriving the budget constraint for alternative utility functions

In the following I derive analogs to equation (2.3.1) for quadratic and CARA preferences. The resulting equations pin down the extensive margin of consumption for a given income, E, and price distribution, $G(p) = 1 - \exp\left\{-\Phi p^\theta\right\}$.

2.A.5.1 Quadratic utility

With quadratic utility we have

$$v'(x) = 1 - a^{quadr} x.$$

So that optimal expenditures are

$$px = \left(a^{quadr} p - \lambda p^2\right).$$

Inserting this and the country specific price distribution into the budget constraint yields

$$E = \left(a^{quadr} \int_0^{p(M)} p\Phi\theta p^{\theta-1} \exp\left\{-\Phi p^{\theta}\right\} dp - \lambda \int_0^{p(M)} p^2 \Phi\theta p^{\theta-1} \exp\left\{-\Phi p^{\theta}\right\} dp\right).$$

Changing variables, $t = \Phi p^{\theta}$, we get

$$E = \left(a^{quadr} \int_0^{p(M)} \left(\frac{t}{\Phi}\right)^{\frac{1}{\theta}} \exp\{-t\}\, dt - \lambda \int_0^{p(M)} \left(\frac{t}{\Phi}\right)^{\frac{2}{\theta}} \exp\{-t\}\, dt\right).$$

Using the first order condition for the extensive margin of consumption, $a^{quadr} = \lambda p(M)$, I can substitute for λ

$$E = a^{quadr} \left(\int_0^{\Phi p(M)^{\theta}} \left(\frac{t}{\Phi}\right)^{\frac{1}{\theta}} \exp\{-t\}\, dt - \frac{1}{p(M)} \int_0^{\Phi p(M)^{\theta}} \left(\frac{t}{\Phi}\right)^{\frac{2}{\theta}} \exp\{-t\}\, dt\right).$$

The integrals are incomplete Gamma functions

$$E = a^{quadr} \left((\Phi)^{-\frac{1}{\theta}} \gamma\left(\frac{1}{\theta} + 1; \Phi p(M)^{\theta}\right) - \frac{1}{p(M)} (\Phi)^{-\frac{2}{\theta}} \gamma\left(\frac{2}{\theta} + 1; \Phi p(M)^{\theta}\right)\right).$$

From the price distribution we have $\Phi p(M)^{\theta} = -\log(1-M)$ and $p(M) = (-\log(1-M)/\Phi)^{-1/\theta}$, so that

$$\begin{aligned} E = {} & a^{quadr} (\Phi)^{-\frac{1}{\theta}} \gamma\left(\frac{1}{\theta} + 1; -\log(1-M)\right) \\ & - a^{quadr} (\Phi)^{-\frac{1}{\theta}} (-\log(1-M))^{-\frac{1}{\theta}} \gamma\left(\frac{2}{\theta} + 1; -\log(1-M)\right). \end{aligned}$$

2.A.5.2 CARA

With CARA we have

$$v'(x) = a^{cara} \exp\left(-a^{cara} x\right).$$

Optimal expenditures are

$$px = -\frac{p}{a^{cara}} \log\left(\frac{\lambda p}{a^{cara}}\right).$$

As the price of the marginal variety is $p(M) = a^{cara}/\lambda$ we can write

$$px = -\frac{p}{a^{cara}} \log\left(\frac{p}{p(M)}\right).$$

Inserting this into the budget constraint

$$E = -\frac{1}{a^{cara}} \int_0^{p(M)} p \log\left(\frac{p}{p(M)}\right) dG(p)$$

and substituting for $p(M)$ and $dG(p)$ we get

$$E = -\frac{\theta\Phi}{a^{cara}} \int_0^{(-\log(1-M)/\Phi)^{\frac{1}{\theta}}} \log\left(\left(-\frac{\log(1-M)}{\Phi}\right)^{-\frac{1}{\theta}} p\right) p^\theta \exp\left(-\Phi p^\theta\right) dp.$$

2.A.6 Data

I use data for the year 2003. In the baseline specification the sample consists of 164 countries, which corresponds to $26732 = 164*163$ bilateral trade relations. In the following I describe the sources of the data that is used in the quantification.

2.A.6.1 Aggregate value of bilateral trade

I use the COMTRADE trade data of the year 2003 as provided by CEPII (Gaulier, Zignago, Sondjo, Sissoko, and Paillacar, 2010). This data set provides the dollar values of the bilateral trade flows between 239 economic entities (mostly countries) on the HS6 level of aggregation $X_{ni}(j)$, which corresponds to 5111 goods categories. Summing over all HS6 categories I get the aggregate value of a bilateral trade flow from exporting country i to the importing country n, $X_{ni} = \sum_{j=1}^{5111} X_{ni}(j)$.

2.A.6.2 Extensive margin of bilateral trade

A simple and intuitive measure for the extensive margin is to count the number of HS6 categories with positive volumes

$$m_{ni} = \sum_j I\left(X_{ni}\left(j\right) > 0\right),$$

where $I\left(X_{ni}\left(j\right) > 0\right)$ is an indicator function taking the value of one if the bilateral trade flow from i to n in the HS6-category j is positive. A potential drawback of this measure is the fact that the HS6-categories are defined for custom purposes, which is why heavily regulated goods tend to have more categories. The associated measurement error is absorbed into the error term and the estimated elasticities are unbiased if the coarseness of the traded HS6-categories is orthogonal to the regressors.

An alternative measure for the extensive margin is brought forward by Broda and Weinstein (2006)

$$m_{ni}^{BW} = \frac{\sum_j X_n\left(j\right) I\left(X_{ni}\left(j\right) > 0\right)}{\sum_j X_n\left(j\right)},$$

where $X_n\left(j\right) = \sum_{k \neq n,i} X_{nk}\left(j\right)$ is the value of country n's total imports in category j. There are two reasons why this measure may be inappropriate in my context. First, this measure is derived using a CES-demand system (Feenstra, 1994), whereas the central assumption in my model is that preferences are non-CES. Second, it has been argued that besides being directly derived from an underlying preference structure the advantage of this measure is that the categories are weighted which may alleviate measurement errors due to differences in the coarseness of the categorization. In the context of my model, the numerator then would represent the extensive margin of bilateral trade, m_{ni}, and the denominator is the multilateral extensive margin of imports, i.e. the measure of varieties that are sourced internationally, $\sum_{k \neq n} m_{nk}$. Using the corresponding expressions from the model one sees that the central element of my theory - the extensive margin of consumption - cancels, $m_{ni}/\sum_{k \neq n} m_{nk} = \pi_{ni}/\left(1 - \pi_{nn}\right)$. In other words the Broda and Weinstein (2006)-measure is unlikely to reflect the income effects coming from the non-homothetic consumer behavior.

2.A.6.3 Per capita incomes and population sizes

The per capita incomes and the population sizes are taken from the Worldbank's World Development Indicator. The per capita incomes are measured in current (year 2000) US-dollars. Following EK I deliberately abstain from using purchasing power adjusted incomes as deviations from PPP arise endogenously in the EK framework.

2.A.6.4 Bilateral distances, shared border, and common language

All transportation cost proxies are from the database provided by CEPII. The bilateral distance is measured as the distance between two countries' most populous cities. The common language indicator takes the value one if two countries have the same official language[30] and common border takes the value one if two countries share a common land-border.

2.A.6.5 CEX

The US consumer expenditure survey (CEX) is a rotating panel collected by the Bureau of Labor Statistics (BLS). Its "interview survey" part provides detailed information on household characteristics and expenditures. One of the main purpose of the survey its use in determining and revising the baskets that are used for the computation of the consumer price index. I obtain the CEX data from the website of the Inter-University Consortium for Political and Social Research (ICPSR). A detailed documentation of the data can be found in BLS (2003). In the following I briefly discuss the raw data and how I processed the raw data.

The unit of observation in the CEX is a "consumer unit", CU, which basically comprises of all members of a household using their income to make joint expenditures.[31] Each CU is in the panel for 5 consecutive quarters with one interview per quarter. The initial interview only collects demographic characteristics, whereas the following four interviews collect expenditures from the previous three months. Expenditures are collected for around 600

[30]The results remain basically unchanged when using major languages instead of official languages.

[31]Under this definition a family constitutes a CU, whereas a roomer living with a family would constitute his own CU as he is financially independent.

categories (represented by “universal classification codes”, UCC). Of these 600 UCCs I select the UCCs that correspond to tradable manufactures. This clearly involves some ad-hoc decisions. I develop two classifications - a conservative classification, where I disregard all uncertain UCCs and a liberal classification, which includes more UCCs. Particularly difficult are housing related items since they are often separated by renter, owned home, and owned vacation home. For the conservative classification I disregard these UCCs all together. In the liberal classification I lump together the renter and owner categories for the same expense, e.g. I combine the categories “Installed and non-installed replacement wall to wall carpeting for owned homes” and “Installed and non-installed original wall to wall carpeting for rental homes” into one category, and ignore UCCs that are only available for either renter or owner such as “Installed and non-installed original wall to wall carpeting for owned homes”. Another difficult class of UCCs is related to cloths - a CU buying “men’s footwear” depends very much on if this CU comprises an adult male. Therefore, in the liberal classification, I lump together UCCs across gender and age, e.g. I collapse “men’s footwear”, “women’s footwear”, “Boys’ footwear”, and “Girls’ footwear” into one category. The conservative classification disregards these categories. In the end, the liberal classification consists of 186 distinct expenditure categories, whereas the conservative classification comprises of 107 categories.

2.A.6.6 Manufacturing absorbtion

I use data from the United Nations Industrial Development Organization (UNIDO, 2003) on gross manufacturing output. For the year 2003 this database provides the gross manufacturing output for 74 countries. Unfortunately, the database does not include gross output for several large countries, most notably China. I therefore choose to impute the gross manufacturing output for countries that belong to the 20 largest economies in 2003 and for which I do not observe gross manufacturing output. I do this by following Eaton, Kortum, and Kramarz (2004) and scaling value added in the manufacturing sector by the average ratio of gross output and value added across countries. These countries are China, Switzerland, Canada, and Mexico.

2.A.6.7 Top quintiles of income distributions

I get data on the top quintiles of the income distributions from UNU-WIDER (2008). A well-known problem of inequality data is that the measure to which the inequality data refer varies across countries. In particular some quintiles refer to expenditures and others to income. Moreover income may be measured in gross or net terms. To correct for this I follow Dollar and Kraay (2002) and regress the observed quintiles on dummies for the underlying measure. I then use the resulting coefficients to estimate the net income quintiles.

Chapter 3

Non-homothetic preferences, parallel imports and the extensive margin of international trade

(This chapter has been written together with Reto Foellmi and Josef Zweimüller)

3.1 Introduction

Theories of international trade typically assume that consumers have homothetic preferences, showing why product differentiation, increasing returns, and firm heterogeneity are crucial in explaining the extensive and intensive margins of international trade (e.g. Krugman, 1980, Melitz, 2003, Helpman, Melitz, and Rubinstein, 2008, Chaney, 2008). While both casual observation and econometric analyses of consumer budgets suggest that homothetic preferences cannot be defended on empirical grounds, their nice aggregation properties and high tractability make them an ideal tool for studying settings in which technology rather than demand factors are the main driving force of aggregate outcomes.

The assumption of homothetic preferences, however, is clearly inappropriate for studying how the composition of aggregate income affects consumption and trade patterns. Consider two countries, Austria and Nigeria. In 2008, their PPP-adjusted national income was roughly of the same order of magnitude (311 bill US $ and 281 bill US $, respectively). While Austria is small and rich, with a population of 8.4 mill and per capita income of 37,680 US $, Nigeria is large and poor, with a population of 152 mill and per capita income of 1,940 US $. Should we expect the two countries to display similar economy-wide demands for a given set of consumer goods? Homothetic preferences predict that the representative Nigerian consumer purchases the same menu of goods as the representative Austrian consumer, but in quantities that are 95 percent lower. If this were so, trade patterns are unaffected by the composition of aggregate income and exclusively shaped by supply conditions such as comparative advantages, differences in factor endowments, trade costs, and other technological asymmetries.

In this chapter, we explore the implications of non-homothetic preferences in the context of the "new" trade theory framework. While the supply side of our model is identical to the basic Krugman (1980) framework, we deviate from this framework by introducing non-homothetic preferences in a very stylized way: we assume that consumer goods are indivisible and either consumed in unit quantity or not consumed at all.[1] Prima facie, this assumption may seem overly simplistic. However it is a "natural" deviation from the standard CES-framework in the following sense. In our framework, consumption choices are about the number of goods – the extensive margin of consumption – while a choice along the intensive margin is ruled out by assumption. This is orthogonal to the standard CES framework where consumption choices only affect the *intensive* margin of consumption and a choice along the along the extensive margin is ruled out by infinite reservation prices (hence even the poorest household will consume all goods in positive, albeit tiny, amounts).

Adopting this stylized way of introducing non-homotheticities provides a simple and tractable framework that leads to equilibrium outcomes quite different from the standard model. To keep things simple and transparent we confine the basic analysis to the most simple case of two countries. *First*, we show that, when per capita endowments of the

[1] Preferences of this type were used, inter alia, by Murphy, Shleifer, and Vishny (1989) to study how demand composition affects technology choices in the development process, by Matsuyama (2000) to study the role of non-homotheticities in Ricardian trade, and by Foellmi and Zweimüller (2006) to study the relationship between inequality and growth.

two countries are very similar, the world economy ends up in a *full trade* equilibrium. In such an equilibrium, all goods are internationally traded and consumed in both countries. In contrast, when per capita endowments of the two countries are sufficiently unequal, a *partial trade* equilibrium emerges. The reason is that only households in the rich country consume all goods produced worldwide whereas households in the poor country can afford only a subset of all goods. In a partial trade equilibrium, the fraction internationally traded goods increases in the similarity of per capita endowments. This result is reminiscent of the "Linder hypothesis", according to which more similar countries trade more intensively with each other.

Second, the partial trade regime provides us with a simple general equilibrium framework of *parallel trade*. The partial trade equilibrium is supported by the price setting behaviors of monopolistic firms. With indivisible goods, the highest price a firm can charge is the representative consumer's willingness to pay which is finite. But this may create arbitrage opportunities. Consider a US firm selling its good both in the US and in China. When price differences are sufficiently large, arbitrage traders will purchase the good cheaply on the Chinese market, ship it back and underbid local producers on the US market. Anticipating this, US firms either set a price such that the incentive for parallel trade vanishes; or US firms do not supply their product on the world market, but therefore can charge the high price in the US. The general equilibrium perspective of our model makes the latter fraction of firms endogenous. This effect is typically not considered in partial equilibrium settings of parallel trade but has a potentially important impact on trade patterns.

Third, we make precise the relative importance of population sizes and per capita endowments for trade patterns. The country with a large population is more productive because a smaller fraction of resources is wasted due to (iceberg) trade costs. When per capita endowment differences are small, a higher population can compensate a lower per capita endowment so that a world economy that is initially trapped in a partial trade equilibrium may switch to a full trade equilibrium as a result of population growth. However, when per capita endowment differences are high, a larger population can never fully compensate for a small per capita endowment. In that case, the world economy remains trapped in partial trade even when the population grows very large. Hence the impact of population size differs crucially from the impact of per capita endowments. A higher degree of similarity in per capita endowments lets the world economy always escape the partial trade regime, whatever the differences in population size of the two countries. In this sense per capita endowments are a more significant determinant of the trade regime than population sizes.

A *fourth* main result of our model concerns the welfare effects of trade. Comparing trade to autarky it turns out that in a full trade equilibrium the poor country gains relatively more from trade; in a partial trade equilibrium, however the rich country gains more. Moreover, a trade liberalization (a reduction in iceberg trade costs) increases welfare of consumers in both countries when the world economy is in a full trade equilibrium. However, in a partial trade equilibrium, a trade liberalization is beneficial for the rich country but actually *hurts* the poor country. The reason is that trade liberalizations deteriorate the poor country's terms of trade, because international price discrimination becomes more limited. Exporters of the poor country need to lower the prices they charge in the rich country to inhibit parallel trade, whereas exporters of the rich country have no need to adjust their export prices. However, they must adjust the prices they charge in their home market. This makes selling on the rich market at unrestricted high prices more attractive - thus, in the new partial trade equilibrium more firms of the rich country will concentrate their sales exclusively only on the home market and less products will be available on the world market. Consumers in the rich country benefit from the decreasing prices of the internationally traded goods, whereas consumers in the poor country are confronted with a lower range of import goods at unchanged prices.

Our basic model is simple enough to be extended in various directions. We first look at a world with more than two countries. It turns out that in a multi-country world our result that a trade liberalization decreases rather than increases trade needs to be qualified. With many rich and many poor countries, a trade liberalization stimulates trade and welfare due to more trade within the rich North and within the poor South.

However, it decreases overall trade (and increases the welfare-gap) between the Northern and the Southern region. While the North gains for sure, also the South may gain when within-South trade increases more strongly than North-South trade falls.

Second, we allow for heterogenous trade costs. When trade costs differ for the various products (but are not too large to inhibit trade at all), trade liberalization implies that goods with high (low) trade costs will be traded more (less). The reason is that high-trade-cost producers can sufficiently price discriminate hence they have an incentive to sell their product also in the poor country. For a low-trade-cost producer a trade liberalization implies fiercer price competition on world markets. Therefore more low-trade cost producers will decide to sell their product exclusively on the rich home market and not to sell abroad. In such a situation, it depends on the relative importance of high-cost and low-cost producers whether a trade liberalization stimulates or dampens international trade.

In a third extension we look at the impact of policy-restrictions on parallel trade. Our basic model assumes "international exhaustion" in which case parallel imports are not legally forbidden. The holder of a product's property right (patent, trademark, copyright) can no longer exercise his property right once this product is sold either on the home market or on the world market - his property rights are exhausted. In contrast, many countries have implemented "national/regional exhaustion" in which case the property right runs out when the product is sold on the home market, but does not run out when the product is sold abroad. It turns out that restrictions to parallel trade help consumers in the poor country but hurt consumers in the rich country. The reason is a general equilibrium effect. Stronger parallel trade restrictions encourage producers of the rich country to sell their product abroad while being able to charge high prices at home. This tends to improve the terms of trade for the poor country.

The fourth extension explores the consequences of income inequality. In such a context the level of trade costs and the extent of within-country inequality determine the equilibrium outcome. For low trade costs there are producers charging high prices selling to the rich at home and abroad and other producers charging low prices selling to all households. Interestingly, in such a situation with low trade costs, where inequality arises within countries and not between countries, lower trade costs actually benefit the poor.

Finally, we show that our model extends to a more general class of preferences where consumers have a choice not only along the extensive margin but also along the intensive margin. We demonstrate that, with more general specifications of preferences, a partial trade equilibrium emerges provided that (i) the derived individual demand functions feature finite reservation prices (so that some consumers optimally choose not to buy certain goods when prices are too high) and (ii) demand elasticities decrease (and mark-ups increase) along the demand function. This makes an equilibrium possible where firms are indifferent between selling at high prices and small quantities in rich economies or low prices and large quantities on the world market so that a partial equilibrium (supported by a threat of parallel trade) emerges.

Several previous papers have incorporated non-homothetic preferences into the new trade theory framework. The classical contributions are Markusen (1986) and Bergstrand (1990) who stick to CES-preferences for differentiad products but introduce non-homotheticities trough a homogenous produc with a minimum consumption requirement.[2] Several recent papers abandon the CES-assumption and instead introduce variable elasticity of substitution (VES-) preferences. One approach, followed by Markusen (2010) and Simonovska (2010) aggregates differentiated consumer goods with a Stone-Geary subutility (with negative required consumption levels). This formulation implies that firms charge higher prices in richer markets, an outcome in line with empirical evidence (see e.g. Hsieh and Klenow, 2007,Simonovska, 2010, and Manova and Zhang, 2009). Sauré (2009) also uses a Stone-Geary subutility and studies how heterogeneous trade costs affect trade patterns among symmetric countries. Behrens and Murata (2009) explore the

[2]Important empirical contributions include Hunter and Markusen (1988), Hunter (1991), Francois and Kaplan (1996), Dalgin, Mitra, and Trindade (2008), and Fieler (2010). Mitra and Trindade (2005) use nonhomothetic preferences over the industry aggregates to study how income inequality affects trade patterns. Chung (2005) used quasihomothetic preferences to address Trefler (1995) missing trade puzzle. Falkinger (1990) uses nonhomothetic preferences in a dynamic innovator-imitator model. Flam and Helpman (1987) consider qualitative product differentiation in a North-South model. This model has been extended by Choi, Hummels, and Xiang (2009), who focus on the role of income distribution in determining the trade patterns. Krishna and Yavas (2005) used consumption indivisibilities in combination with labor market imperfection to explain possible losses from trade in transition economies.

pro-competitive effects of free trade when consumers have CARA-preferences. They find that trade reduces mark-ups and that low-income countries gain more from trade than high income countries. These papers focus on symmetric equilibria, i.e. equilibria where all goods are consumed by all households worldwide.[3] Their approaches differ from that of ours, which focuses on the (asymmetric) partial trade equilibrium where some goods are consumed by all households worldwide, whereas other goods are only affordable to households in the rich country.

As mentioned above, we contribute to the literature by presenting a general equilibrium model of parallel trade. A large partial-equilibrium literature has explored the determinants and consequences of parallel trade (see Maskus, 2000, and Ganslandt and Maskus, 2007, for surveys). The empirical relevance and importance of parallel trade is undisputed. The question whether parallel imports should be permitted or not (or inhibited by appropriate policies) triggers hot political debates in many countries. While empirical evidence on the quantitative importance of parallel trade is hard to get, existing estimates suggest that parallel imports are quantitatively important. A large body of empirical evidence has looked at the pharmaceuticals market, where the pros and cons of parallel trade are most obvious (see Ganslandt and Maskus, 2004, for an interesting study of parallel trade on prices of pharmaceuticals in the EU). However, parallel trade is quantitatively important in many other industries. For instance, KPMG (2003) estimates that grey market sales of IT products could exceed USD 40 billion annually and that price advantages drive grey market activity. According to the estimates of the National Economics Research Association (NERA), parallel imports account for between 5% and 20% of trade within the EU for goods such as consumer electronics, cosmetics and perfumes, musical recordings, and soft drinks (NERA, 1999). In other words, parallel trade is an important phenomenon and relevant in many markets. It is therefore interesting to study the determinants and consequences of parallel trade (and/or the threat of it) in a general

[3] Other papers that give up the standard CES framework have studied the role of income inequality on trade patterns. Fajgelbaum, Grossman, and Helpman (2009) use a nested logit demand system in which income distribution affects quality choice and patterns of trade. Desdoigts and Jaramillo (2009) adopt Lancaster's ideal variety approach to study the impact of inequality on trade patterns.

equilibrium framework.[4]

The remainder of this chapter is organized as follows. In the next Section, we present the basic assumptions and discuss the consumer behavior with non-homothetic preferences. Section 3.3 first discusses the closed economy case and then applies our basic framework to study patterns of trade among equally large but unequally rich countries. Section 3.5 discusses the role of population size versus per capita incomes. Section 3.6 extends the model to other relevant settings such as a multi-country world, restrictions to parallel trade, income inequality within countries. Section 3.7 discusses more general specifications of preferences. Section 3.8 concludes.

3.2 The model

The economy is populated by $\mathcal{P}$ identical households. Each household is endowed with L units of labor, the only production factor. Labor is perfectly mobile within countries and immobile across countries. The labor market is competitive and the wage is W. Hence household income is $y = WL$. Production requires a fixed labor input F to set up a new firm and a variable labor input $1/a$ to produce one unit of output, the same for all firms.[5] Producing good j in quantity $x(j)$ thus requires a total labor input of $F + x(j)/a$. Product markets are imperfectly integrated in the sense that trade costs accrue when goods are traded internationally. Iceberg trade costs imply that $\tau \geq 1$ units have to be shipped to the other country in order for 1 unit to arrive at the destination.

Households spend their income on a continuum of differentiated goods, indexed by j. We assume that good j yields positive utility only for the first unit and zero utility for any additional units. Hence consumption is a binary choice: either you buy or you don't buy. Denote an indicator $x(j)$ that takes value 1 if good j is purchased and value 0 if not.

[4] Note that due to the static setting, we do not need to introduce patents. The design of patents is crucial for the outcomes in a dynamic setting. Grossman and Lai (2004) and Grossman and Lai (2006) discuss these models.

[5] An extensive literature has documented the importance of productivity differences between firms. While relaxing the assumption of homogeneous firms is straightforward, we stick to it in order to keep the supply side of the model as simple as possible, allowing us to focus on the new effects due to the demand side.

Then utility takes the simple form

$$U = \int_0^\infty x(j)dj, \quad \text{where } x(j) \in \{0, 1\}. \tag{3.2.1}$$

Notice that utility is additively separable and that the various goods enter symmetrically. Hence the household's utility is given by the number of consumed goods.

Now consider a household with income y which can choose among (a measure of) N goods that are supplied at prices $\{p(j)\}$.[6] The problem is to choose $\{x(j)\}$ to maximize the objective function (3.2.1) subject to the budget constraint $\int_0^N p(j)x(j)dj = y$. Denoting λ as household's marginal utility of income, the first order condition can be written as

$$\begin{aligned} x(j) &= 1 \text{ if } 1 \geq \lambda p(j) \\ x(j) &= 0 \text{ if } 1 < \lambda p(j) \end{aligned}$$

Rewriting this condition as $1/\lambda \geq p(j)$ yields the simple rule that the household will purchase good j if the household's willingness to pay $1/\lambda$ does not fall short of the price $p(j)$.[7] The resulting demand curve, depicted in Figure 3.1, is a step function which coincides with the vertical axis for $p(j) > 1/\lambda$ and equals unity for prices $p(j) \leq 1/\lambda$.

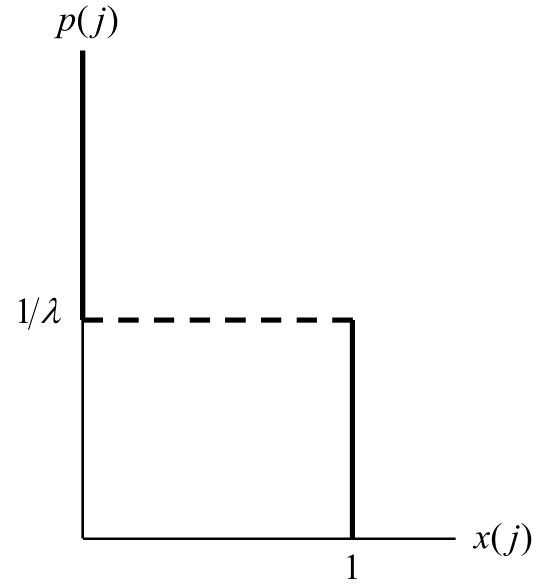
By symmetry, the household's willingness to pay is the same for all goods and equal to the inverse of λ, which itself is determined by the household's income and product prices. Intuitively, the demand curve shifts up when the income of the consumer increases (λ falls) and shifts down when the price level of all other goods increases (λ rises).

It is interesting to note the difference between consumption choices under 0-1 preferences and under the standard CES-case. With 0-1 preferences the household chooses how many goods to buy but there is no choice about the quantity in which a good is

[6] Notice that the integral in (3.2.1) runs from zero to infinity. While preferences are defined over an infinitely large measure of potential goods, the number of goods actually supplied is limited by firm entry, i.e. only a subset of potentially producible goods can be purchased at a finite price.

[7] Strictly speaking, the condition $1 \geq \lambda p(j)$ is necessary but not sufficient for $c(j) = 1$ and the condition $1 < \lambda p(j)$ is sufficient but not necessary for $c(j) = 0$. The reason is that purchasing all goods for which $1 = \lambda p(j)$ may not be feasible given the consumer's budget. For when N different goods are supplied at the same price p but $y < pN$ the consumer picks at random which particular good will be purchased or not purchased. This case, however, never emerges in the general equilibrium.

Figure 3.1: microeconomic demand function



consumed.[8] Under CES preferences, a household has a choice about the (positive) quantities of the supplied goods, but essentially has no choice about how many different goods to buy (due to a reservation price of infinity it is optimal to purchase each product in positive amounts, whatever its price). In other words, the stylized case of 0-1 preferences is interesting because this assumption shifts the focus of consumer choice to the *extensive* margin, thus deviating from the CES case with its focus on the *intensive* margin. In Section 3.7 we show that our results generalize to more general preferences, allowing for adjustments on both the extensive and the intensive margin.

3.3 Autarky equilibrium and the emergence of trade

Consider an economy living in autarky under monopolistic competition. After incurring the set-up costs, the various producers have a natural monopoly for their products. Since all monopolists have the same cost and demand curves and since there is a representative consumer, we can omit indices. The monopolistic firm faces a demand curve as depicted in

[8] The discussion here rules out the case where incomes could be larger than pN, meaning that the consumer is subject to rationing (i.e. he would want to purchase more goods than are actually available at the available prices). While this could be a problem in principle, it will never occur in the equilibrium of the model.

Figure 3.1. This firm will charge a price equal to the representative consumer's willingness to pay $p = 1/\lambda$ and sell output of quantity 1 to each of the $\mathcal{P}$ households.

Without loss of generality, we choose labor as the numéraire and set $W = 1$. Two conditions characterize the autarky equilibrium. The *first* is the zero-profit condition, ensuring that operating profits cover the entry costs but do not exceed them to deter further entry. Entry costs are $FW = F$ and operating profits are $[p - W/a]\,\mathcal{P} = [p - 1/a]\,\mathcal{P}$. The zero-profit condition can be written as $p = (aF + \mathcal{P})\,/a\mathcal{P}$.[9] This implies a mark-up μ - the ratio of price to marginal cost – given by

$$\mu = \frac{aF + \mathcal{P}}{\mathcal{P}}.$$

which is determined by technology parameters a and F and the market size parameter $\mathcal{P}$. The *second* equilibrium condition is a resource constraint ensuring that there is full employment $\mathcal{P}L = FN + \mathcal{P}N/a$. From this equation, equilibrium product diversity in the decentralized equilibrium can be calculated[10]

$$N = \frac{a\mathcal{P}}{aF + \mathcal{P}}L.$$

Market size and technology influence mark-ups in our framework. We will show below that the mark-up channel is a crucial channel by which non-homothetic preferences affect patterns of trade and the international division of labor.

Now assume there are two countries, rich and poor, and consumers in both countries have the same preferences given by (3.2.1). Assume further that firms in the two countries produce different products. Under which condition will the two countries trade?

[9]Notice that we have argued that $p = 1/\lambda$ and $p = (aF + P)\,/aP$; it therefore seems that p is overdetermined, unless we have $\lambda = aP/\,(aF + P)$. To see that this is in fact the case, notice that increasing income by one unit approximates an increase in L (because income is $y = WL$ and we normalized $W = 1$). Hence we can write $\lambda = dU/dL = (\partial U/\partial N) \cdot (\partial N/\partial L)$. Since we have $U = N$, $\partial U/\partial N = 1$, and we have $\partial N/\partial L = aP/\,(aF + P)$ from equilibrium product diversity, this confirms the claim.

[10]Notice the difference between the 0-1 outcome and the standard CES-case. With CES, the mark-up is determined by the elasticity of substitution between differentiated goods; it is independent of technology and market size. In fact, the variability of the mark-up with 0-1 preferences will drive many of our results below. Moreover, with CES, equilibrium product diversity is independent of productivity a and proportional to set-up costs F and inversely proportional to market size P. We notice that with 0-1 preferences product diversity in the decentralized equilibrium is equal to the socially optimal product diversity.

Assumption 1. (Trade Condition) $\tau \leq \sqrt{aF/\mathcal{P}+1}$.

The above assumption states a sufficient condition for the emergence of international trade. To see this, consider an entrepreneur shipping τ^2 units of his or her product to the other country so that, due to iceberg trade costs, τ units arrive there. The firm can exchange the remaining τ units for τ units of a (symmetric) foreign variety ship it back and sell it on the home market at price p. Thus autarky cannot be an equilibrium if the costs of producing τ^2 units falls short of the (local) autarky prize, i.e. $\tau^2/a < (aF+\mathcal{P})/a\mathcal{P}$. Solving for τ yields the trade condition. Note that the trade condition is independent of the other country's parameters such as population size, labor endowment, or technology parameters. The above trade condition is a sufficient but not a necessary condition for the emergence of international trade. We will assume throughout the main text that Assumption 1 holds.[11]

3.4 Trade between equally large but unequally rich countries

Let us now assume that Assumption 1 holds and consider a world economy with two countries with unequal wealth. We denote variables of the rich country with superscript R and variables of the poor country with superscript P. To highlight the importance of differences in per capita incomes as a source of international trade, we start by assuming that the two countries differ only in per capita endowments, but have equally large populations, hence $L^R > L^P$ and $\mathcal{P}^R = \mathcal{P}^P = \mathcal{P}$. We also assume that the two countries have identical production and transport technologies.

3.4.1 A full trade equilibrium

When the two countries are not very unequal, a possible equilibrium is one in which all producers sell on the world market, so that all goods are traded internationally. In such a *full trade equilibrium*, the price for a differentiated product in country $i = R, P$

[11] The case when Assumption 1 does not hold (high trade costs), is discussed in the Appendix.

equals the respective households' aggregate willingness to pay (see Figure 3.1), hence we have $p^R = 1/\lambda^R$ and $p^P = 1/\lambda^P$. Since country R is wealthier than country P, we have $\lambda^R < \lambda^P$ and $p^R > p^P$. By symmetry, the prices of imported and home-produced goods are identical within each country.

Solving for the full trade equilibrium is straightforward. Consider the resource constraint in the rich country. When N^R firms enter, $N^R F$ labor units are employed to set up these firms and $N^R \mathcal{P}(1+\tau)/a$ labor units are employed in the production to serve the world market. Since each of the $\mathcal{P}$ households inelastically supplies L^R units of labor, the resource constraint is $\mathcal{P}L^R = N^R F + N^R \mathcal{P}(1+\tau)/a$. This is analogous for the poor country P. Solving for N^i lets us determine the number of active firms in the two countries

$$N^i = \frac{a\mathcal{P}}{aF + (1+\tau)\mathcal{P}} L^i, \; i = R, P.$$

Now consider the zero-profit conditions in the two countries. An internationally active firm in the rich country generates total revenues equal to $\mathcal{P}(p^R + p^P)$ and has total costs $W^R [F + (1+\tau)\mathcal{P}/a]$. An internationally active firm in the poor country generates the same total revenues and has to incur the same labor requirement $F + (1+\tau)\mathcal{P}/a$. Hence, wages per efficiency unit have to equalize, $W^R = W^P$, for the zero profit conditions to hold in both countries. We use labor as the numéraire in the following, $W^R = W^P = 1$. The budget restrictions are therefore $p^i \left(N^R + N^P\right) = L^i$. Combining the zero profit condition with the budget restrictions and the number of firms lets us express the price charged in country i as

$$p^i = \frac{L^i}{L^R + L^P} \frac{aF + (1+\tau)\mathcal{P}}{a\mathcal{P}}, \; i = R, P. \tag{3.4.1}$$

The prices of all differentiated products are the same within a country, irrespective of whether they are produced at home or abroad. Consequently, imported goods generate a lower mark-up than locally produced goods as exporters have to bear the trade costs fully.[12] The mark-ups (price over marginal cost) producers charge on their home market

[12] In this respect, 0-1 preferences differ strongly from CES preferences, as higher costs cannot be passed through to prices. With CES preferences, transportation costs are more than passed through to prices as

$\mu_D^i = ap^i$ and the mark-ups set in the export market $\mu_X^i = ap^i/\tau$ are given by

$$\mu_D^i = \frac{L^i}{L^R + L^P} \frac{aF + (1+\tau)\mathcal{P}}{\mathcal{P}}, \text{ and } \mu_X^i = \frac{1}{\tau} \frac{L^i}{L^R + L^P} \frac{aF + (1+\tau)\mathcal{P}}{\mathcal{P}}, \; i = R, P.$$

In sum, the full trade equilibrium has a simple structure: the ratios of rich relative to poor country varieties, prices, and mark-ups are identical to the ratio in relative labor endowments (and nominal incomes), i.e. $N^P/N^R = p^P/p^R = \mu_D^P/\mu_D^R = \mu_X^P/\mu_X^R = W^P L^P/\left(W^R L^R\right) = L^P/L^R < 1$. The differences in per capita endowments and incomes translate one-to-one into differences in prices, hence international trade establishes an equilibrium such that real incomes and welfare levels equalize between the two countries. Under autarky, on the other hand, the poor country is clearly worse off than the rich country. As a result, international trade benefits the poor country more than it does the rich country.

3.4.2 Partial trade and the threat of parallel imports

Full trade cannot be an equilibrium outcome when per capita labor endowments and hence incomes between the two countries are very unequal, i.e. when L^P/L^R becomes small. The reason is that if countries are sufficiently unequal, a threat of parallel trade emerges. To see the point most clearly, consider a US firm that sells its good both in the US and in China. The firm charges a price in China that equals a Chinese household's willingness to pay $p^P = 1/\lambda^P$ and a price in the US that equals the US households willingness to pay $p^R = 1/\lambda^R$. Because the difference between $1/\lambda^P$ and $1/\lambda^R$ is large, arbitrage opportunities emerge. Arbitrage traders purchase the good cheaply on the Chinese market, ship it back to the US, and underbid local producers on the US market. This threat of parallel trade also concerns Chinese firms which both produce for the local market and export to the US. When these firm charge prices in the US that exploit US households' high willingness to pay, arbitrage traders have an incentive to purchase the

exporters charge a fixed mark-up on marginal costs (including transportation). Notice limited cost pass-through is consistent with empirical evidence. A number of empirical studies document that marginal cost shocks are not fully passed through to prices at the firm level and that prices are substantially less volatile than costs. See Ravn et al. (2007) and the references quotes there.

product in China cheaply and parallel export it to the US.

Clearly, firms anticipate this threat of parallel trade and adjust their international pricing accordingly. These firms thus take advantage of the large world market but are constrained in their pricing due to the threat of parallel trade. There is an alternative, potentially profitable, strategy: a rich-country firm could abstain from trading its product internationally and focus exclusively on its rich home market. This producer type has a smaller market but can exploit the rich country households' high willingness to pay because it is not subject to the threat of parallel imports. In equilibrium, both types of firms exist simultaneously and the relative popularity of the two strategies adjusts such that both yield the same profits. (We will see below that all firms in the poor country are strictly better off selling their product on the world market rather than limiting their sales to exports to the rich country and not selling on the local market.) This implies that only a subset of all available products is actually traded, which is why we call this equilibrium "partial trade" equilibrium.

Denote the price in the rich country of a good that is traded internationally by p_T^R ; the price in the rich country of a good that is not traded by p_N^R; and (as above) the price of a good in the poor country by p^P. When setting their prices, suppliers of goods traded internationally anticipate the threat of parallel trade and set a price that just prevents any incentive for arbitrage. This implies that the prices charged in the rich country for goods traded internationally may not exceed the corresponding prices for these goods in the poor country plus trade costs, i.e. $p_T^R \leq \tau/\lambda^P$, profit maximization implies that this condition holds with equality. Hence we must have $p_N^R = 1/\lambda^R$, and $p^P = 1/\lambda^P$.

The zero profit condition for a traded good is $(p_T^R + p^P)\mathcal{P} = [F + \mathcal{P}(1+\tau)/a]\, W^R$ for an internationally active rich-country producer and $(p_T^R + p^P)\mathcal{P} = [F + \mathcal{P}(1+\tau)/a]\, W^P$ for a poor-country producer. Both types of firms generate the same total revenues and have to incur the same labor input. As a result, the zero-profit condition requires the compensation per efficiency unit of labor to be the same in the two countries, $W^R = W^P = 1$. The prices of traded goods can be calculated straightforwardly from these zero profit conditions as

$$p_T^R = \frac{\tau}{1+\tau}\frac{aF + (1+\tau)\,\mathcal{P}}{a\mathcal{P}} \quad \text{and} \quad p^P = \frac{1}{1+\tau}\frac{aF + (1+\tau)\,\mathcal{P}}{a\mathcal{P}}.$$

The zero profit condition for a rich-country producer that sells his product exclusively on the home market is $p_N^R\mathcal{P} = F + \mathcal{P}/a$, from which we calculate the equilibrium price of a non-traded variety

$$p_N^R = \frac{aF + \mathcal{P}}{a\mathcal{P}}.$$

In a partial trade equilibrium, domestic and internationally active firms co-exist in equilibrium. To see why this is an equilibrium, consider the alternative situation in which all goods produced in the rich country are traded internationally. If all products were sold at a price that prevented parallel trade, all goods would be priced below the rich-country households' willingness to pay. However, this corresponds to a situation where the representative rich-country household is not able to spend all income. This, in turn, implies that country-R households have an infinitely large willingness to pay for additional products, which induces some country-R firms to switch strategy and sell only on their home markets.

In contrast to the rich country, do all producers in the poor country sell their product both at home and abroad? In principle one might think that country-P producers also have an incentive to sell their product exclusively in the rich country exploiting the country-R households' high willingness to pay (and not to sell their product on the home market to prevent parallel exports). While such a strategy generates the same total sales, it generates high overall costs as the country-P exporter also has to bear trade costs. Hence selling exclusively on the R market is not a profitable option for a P producer.

We are now ready to solve for the partial trade equilibrium. The resource constraint in the poor country is still given by $\mathcal{P}L^P = N^P\,(F + (1+\tau)\mathcal{P}/a)$ from which we calculate

$$N^P = \frac{a\mathcal{P}}{aF + (1+\tau)\mathcal{P}}L^P. \tag{3.4.2}$$

The resource constraint in country R is different from before because now we have to distinguish products that are exclusively sold domestically and those that are traded internationally. Denoting the traded and non-traded goods produced in the rich country by N_T^R and N_N^R, respectively, the resource constraint of country R is $\mathcal{P}L^R = N_T^R\,(F + (1+\tau)\mathcal{P}/a)$ $+N_N^R\,(F + \mathcal{P}/a)$. Together with the trade balance condition $N_T^R p^P \mathcal{P} = N^P p_T^R \mathcal{P}$ and the terms of trade $p_T^R/p^P = \tau$ we can calculate

$$N_T^R = \frac{a\mathcal{P}}{aF + (1+\tau)\,\mathcal{P}}\tau L^P, \quad \text{and } N_N^R = \frac{a\mathcal{P}}{aF + \mathcal{P}}\left(L^R - \tau L^P\right). \tag{3.4.3}$$

3.4.3 Per capita incomes and patterns of trade

It is straightforward to see the condition under which the threat of parallel trade becomes a binding constraint on price setting in the rich country, allowing a partial trade equilibrium to emerge. In a full trade equilibrium, relative prices are $p^P/p^R = L^P/L^R$ and the threat of parallel trade is not binding as long as the price ratio satisfies $p^R/p^P \leq \tau$. It follows that the parallel trade constraint kicks in when

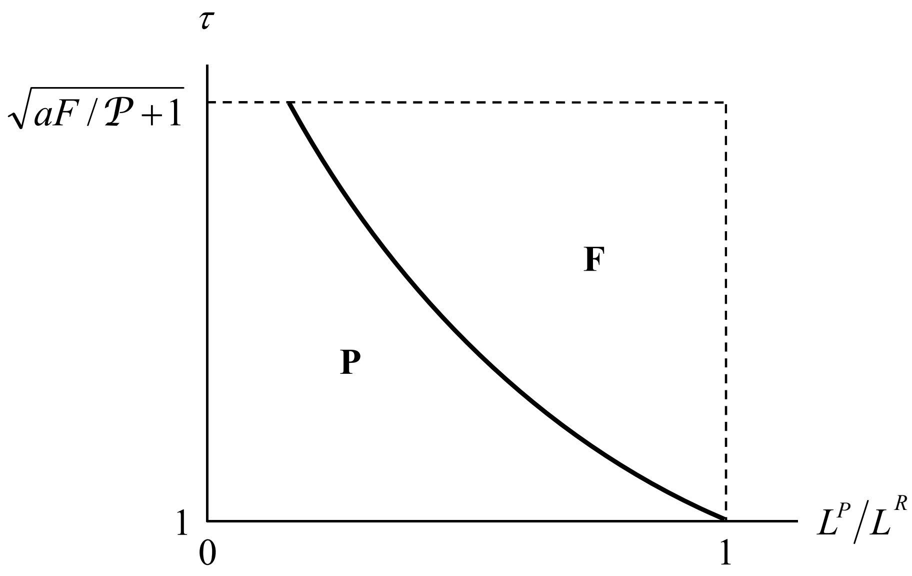
$$\tau = \frac{L^R}{L^P}. \tag{3.4.4}$$

In other words, a full trade equilibrium emerges when per capita incomes are sufficiently similar, $L^R/L^P \leq \tau$, and a partial trade equilibrium emerges when the gap in per capita incomes is high, $\tau < L^R/L^P$.

Figure 3.2 draws condition (3.4.4) in the $(L^P/L^R, \tau)$ space. Figure 3.2 is drawn for values of τ that satisfy the trade condition of Assumption 1. In region **F** (full trade), characterized by high values of L^P/L^R and intermediate values of τ, there is full trade.

In that region, consumers in the two countries have very similar incomes (and hence the differences in their willingness to pay are minor) so that the parallel trade constraint on prices in the rich market does not become binding and arbitrage opportunities do not emerge. In region **P** (partial trade), characterized by low trade costs and high differences in average incomes, a partial trade equilibrium emerges. When relative endowments L^P/L^R are low, the difference in willingness to pay between rich- and poor-country house-

Figure 3.2: partial vs. full trade equilibria



holds is large, making the parallel-trade constraint binding.[13]

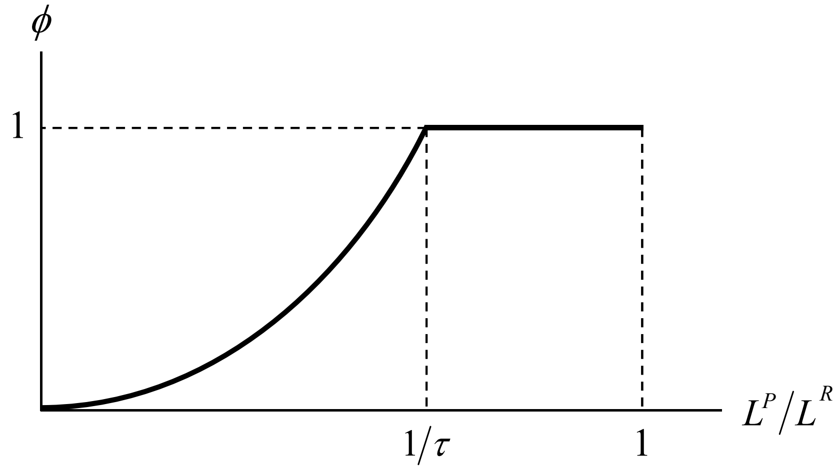
Let us highlight how the volume and structure of international trade depend on relative per capita incomes L^P/L^R. We define "trade intensity" ϕ as the fraction of traded goods, $N^P+N_T^R$, over the total goods produced worldwide, $N^P+N_T^R+N_N^R$. Using equations (3.4.2) and (3.4.3) calculating trade intensity in a partial trade equilibrium is straightforward.

$$\phi = \frac{(1+\tau)(1+aF/\mathcal{P})}{1+aF/\mathcal{P}-\tau^2+(1+\tau+aF/\mathcal{P})\,L^R/L^P} \text{ if } L^P/L^R < 1/\tau, \tag{3.4.5}$$

Alternatively, the world economy is in a full trade equilibrium with $\phi = 1$ if $L^P/L^R \geq 1/\tau$. Equation (3.4.5) reveals that a higher L^P/L^R, i.e. higher similarity between the two countries, is associated with a higher trade intensity ϕ. In Figure 3.3 we draw ϕ (vertical axis) against relative labor endowments L^P/L^R (horizontal axis) holding worldwide resources $\mathcal{P}\left(L^R+L^P\right)$ constant. (A decrease in L^P/L^R is then a mean-preserving spread in world endowments.) A reduction in L^P/L^R leads to a lower intensity of trade: a decreasing range of traded goods $N^P+N_T^R$ is associated with an increasing range of non-traded goods N_N^R. In other words as the similarity of the two countries in per capita endowments

[13]Notice that there is international trade even when income differences become extremely large and L^P/L^R becomes very small. The range of traded goods approaches zero, however, when L^P/L^R goes to zero.

Figure 3.3: trade intensity as a function of relative per capita endowments



(and per capita incomes) increases, the intensity of trade ϕ increases as well. The world economy reaches full trade when $L^P/L^R \geq 1/\tau$. We summarize this discussion in

Proposition 1. a) *When relative per capita endowments are sufficiently similar so that* $L^P/L^R \in [1/\tau, 1]$*, the general equilibrium features full trade.* b) *When per capita endowments become sufficiently dissimilar so that* $L^P/L^R \in (0, 1/\tau)$*, the general equilibrium is characterized by partial trade where a threat of parallel imports/exports constrains the prices charged for internationally traded goods in the rich country.*

Proof. In text □

It is worth noting that this simple model features the famous Linder hypothesis. Linder (1961) emphasized that the similarity of two countries, as measured by similarity in their per capita incomes, should be an important determinant of trade between them.

3.4.4 Welfare and the gains from trade

We proceed by studying welfare implications and the gains from trade. In particular, we are interested in how trade liberalizations (a reduction of τ) affect welfare and the distribution of trade gains between rich and poor countries. In a *full trade* equilibrium, households in both countries purchase all goods produced worldwide. Hence the welfare levels are identical in both countries despite their unequal endowment with productive resources

$$U^{R,f} = U^{P,f} = a\frac{\mathcal{P}\left(L^R + L^P\right)}{aF + (1+\tau)\mathcal{P}}.$$

Firms' price setting behavior drives this result. R-consumers are willing to pay higher prices than P-consumers because their *nominal* income is higher. In the full trade equilibrium, higher nominal incomes translate one to one into higher prices. *Real* incomes and welfare are therefore identical. To see the mechanism by which welfare is equalized even though the two countries have unequal welfare levels under autarky, consider firms' mark-ups. By assumption, all firms have identical production costs hence different prices reflect differences in mark-ups across countries. Since in equilibrium profits are zero, the markups are fully used to cover fixed costs and iceberg losses during transportation. Hence, the higher mark-ups in the rich country imply that the rich country households bear a larger share of these costs.

In a *partial trade* equilibrium, welfare levels of consumers in the two countries diverge. Country-P households purchase $N_T^R + N^P$ goods and country-R households purchase $N^P + N_T^R + N_N^R$ goods. Using (3.4.2) and (3.4.3) we can calculate the welfare levels

$$\begin{aligned} U^{P,p} &= a\frac{\mathcal{P}(1+\tau)L^P}{aF + (1+\tau)\mathcal{P}} \quad \text{and} \\ U^{R,p} &= a\frac{\mathcal{P}(1+\tau)L^P}{aF + (1+\tau)\mathcal{P}} + a\frac{\mathcal{P}\left(L^R - \tau L^P\right)}{aF + \mathcal{P}}. \end{aligned}$$

Notice that while welfare in country R decreases in τ (lower trade costs or trade liberalization increases welfare), the opposite is true for country-P welfare. We are now able to state the following proposition.

Proposition 2. a) *Compared with autarky, country P gains more from trade than country R.* b) *R-consumers favor free trade, i.e. $\tau = 1$, whereas P-consumers derive their highest utility when there are trade barriers such that $\tau = \min\left\{\sqrt{aF/\mathcal{P} + 1}, L^R/L^P\right\}$.*

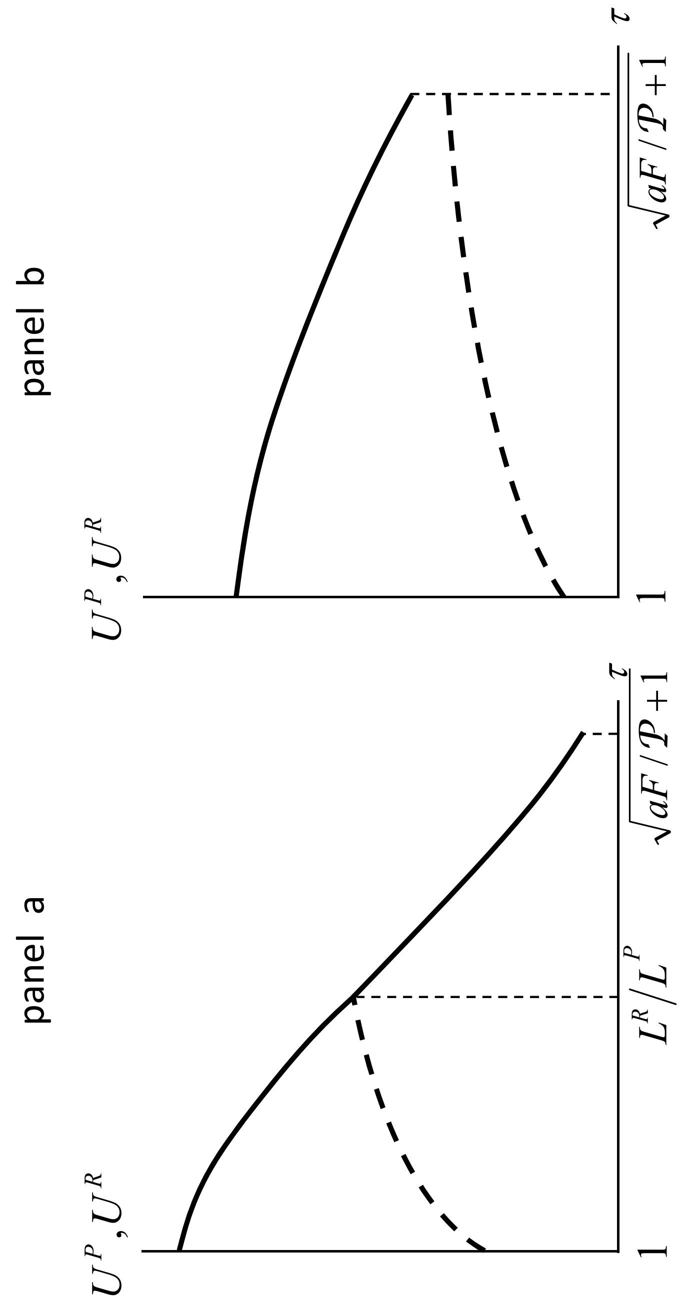
Proof. The proposition can be readily demonstrated using Figure 3.4. Panel a) is drawn for the case when $L^R/L^P \leq \sqrt{aF/\mathcal{P} + 1}$ so that a full trade equilibrium emerges with moderate trade costs. Panel b) is drawn for the case when $L^R/L^P > \sqrt{aF/\mathcal{P} + 1}$ so that a full trade equilibrium is not feasible. Country-R welfare (the bold graph) is monotonically decreasing in τ in both panels of Figure 3.4. Hence the R-consumer reaches his maximum welfare when trade costs have reached their lowest possible level, at $\tau = 1$. However, the welfare of country P (the dotted graph) increases in τ in both panels of Figure 3.4 when trade costs are sufficiently low, i.e. in a situation where the world economy is in a partial trade equilibrium. A full trade regime emerges in panel a) when $\tau \in \left[L^R/L^P, (aF/\mathcal{P}+1)\, L^P/L^R\right]$ where welfare decreases in τ. The economies remain autarkic for even higher $\tau > (aF/\mathcal{P}+1)\, L^P/L^R$ where welfare obviously becomes independent of τ. Figure 3.4 also shows that the highest welfare for country-P consumers occurs at $\tau = L^R/L^P$ when $L^R/L^P \leq \sqrt{aF/\mathcal{P}+1}$ and at $\tau = \sqrt{aF/\mathcal{P}+1}$ when $L^R/L^P > \sqrt{aF/\mathcal{P}+1}$. Taken together, this yields the result in Proposition 2. □

Proposition 2 shows the crucial role of trade costs for welfare. Unequal countries have different preferred trade barriers (or different preferred degrees of trade liberalizations). Consumers in the rich country are essentially free-traders whereas consumers in the poor country only want liberalization up to a positive level of trade costs. What is the intuition behind this result? When the world economy has reached a partial trade equilibrium the threat of parallel imports constrains prices in the rich country to $p_T^R = \tau p^P$. Further trade liberalization forces country-P exporters to lower prices in country-R relative to prices in country P because price discrimination is limited by factor τ. Hence the terms of trade for the poor country deteriorate leading to the welfare loss.

3.5 Population sizes versus per capita endowments

In the previous Section, differences in incomes across countries were due to differences in per capita endowments and the two countries had equally large populations. Let us now consider the case when countries differ along both dimensions. This is interesting because it allows us to gain insights on how the composition of aggregate income affects the extensive margin of international trade under non-homothetic preferences (as standard new trade theory also predicts that the two countries' sizes affect trade volume).

Figure 3.4: welfare and trade costs



With 0-1 preferences it becomes most transparent how the composition of aggregate income affects the size of the home market if one considers a given product. As every household consumes exactly one unit of a given variety, a larger endowment of the representative home-consumer leaves the size of the home market unchanged. For the same reason, a larger population increases the home market one to one. For internationally active producers, having a relatively larger home market means that trade costs are a relatively smaller part of total costs. As firms located in a large country bear relatively fewer iceberg losses as a fraction of their total costs, labor in a large country is more productive than labor in a small country.

3.5.1 Relative wages and general equilibrium

To see how different population sizes affect relative wages, we need to check the zero-profit conditions of internationally active firms. Total revenues are given by $p^P\left(\tau\mathcal{P}^R+\mathcal{P}^{\mathcal{P}}\right)$ and do not differ by firm location. However, the amount of labor needed to serve the world market does differ. It is given by $F+\left(\mathcal{P}^R+\tau\mathcal{P}^{\mathcal{P}}\right)/a$ for country-R firms and by $F+\left(\tau\mathcal{P}^R+\mathcal{P}^{\mathcal{P}}\right)/a$ for country-P firms. We can calculate relative wages from the zero-profit conditions (note that the formula is the same under both full and partial trade)

$$\omega \equiv \frac{W^P}{W^R}=\frac{aF+\tau\mathcal{P}^P+\mathcal{P}^R}{aF+\mathcal{P}^P+\tau\mathcal{P}^R}. \tag{3.5.1}$$

It follows that $\omega \gtreqless 1$ if $\mathcal{P}^P/\mathcal{P}^R \gtreqless 1$. Hence the compensation per efficiency unit of labor is higher in the poor country when the poor country is larger and vice versa.

The discussion above suggests that a backward country in terms of per capita *endowment* can get ahead in terms of per capita *income* if it has a large population. This raises an interesting question. Could it be that a huge population raises incomes and willingness to pay in country P so much that the parallel-trade constraint on price setting becomes binding in country P rather than in country R? In other words, is it possible that producers in a poor country with a large population face a threat of parallel trade leading to a "reversed" partial trade equilibrium in which only a subset of poor-country varieties are internationally traded?

The answer is no. To see this, recall that the households' budget constraints in a full trade equilibrium are $W^iL^i = p^i(N^P + N^R)$, $i = R, P$ from which we can calculate relative prices under full trade

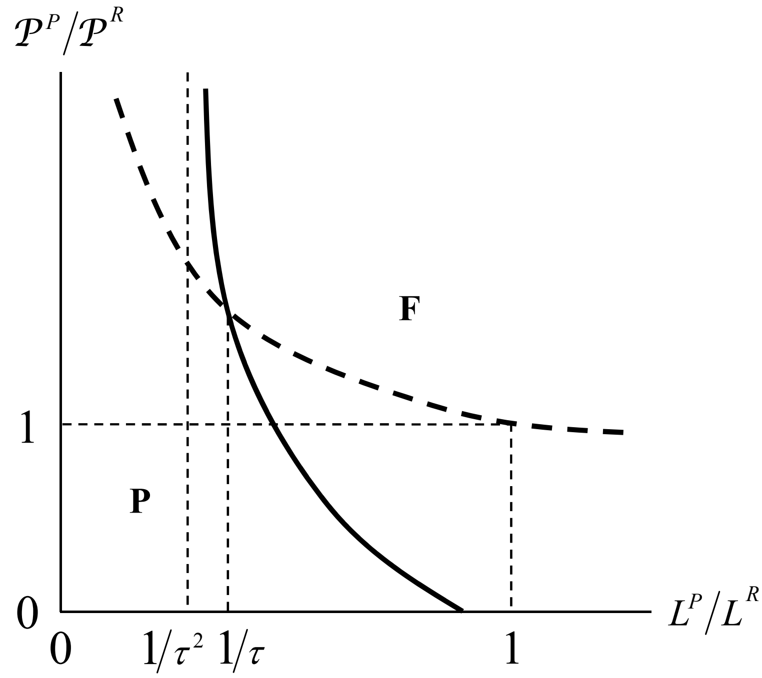
$$\frac{p^P}{p^R} = \frac{aF + \mathcal{P}^R + \tau\mathcal{P}^{\mathcal{P}}}{aF + \tau\mathcal{P}^R + \mathcal{P}^{\mathcal{P}}}\frac{L^P}{L^R}.$$

Verification that $\lim_{\mathcal{P}^P\to\infty} p^P/p^R = \tau L^P/L^R < \tau$ is straightforward. Even if the population in country P becomes extremely large, country-P households' willingness to pay – while eventually exceeding that of country-R households – will remain below τp^R. Hence arbitrage opportunities and therefore a threat of parallel trade do not exist. In sum, a "reversed" partial trade equilibrium will never emerge.

Figure 3.5 demonstrates that per capita incomes affect trade volumes for a given aggregate size of the economy. The bold line represents the combinations of relative per capita endowments and relative population sizes such that the world economy just enters the full trade regime (FP-boundary). More precisely, along this line the relative willingness to pay p^R/p^P are exactly equal to trade costs τ. Per capita incomes are more similar to the right of this curve (L^P/L^R closer to unity) so that the relative willingness to pay is strictly lower than τ. Per capita income differences are too dissimilar to the left of this curve, creating a threat of parallel trade so that a partial equilibrium emerges.[14] The figure shows that, whatever relative population sizes $\mathcal{P}^P/\mathcal{P}^R$, the world economy can reach a full trade equilibrium provided that relative per capita endowments L^P/L^R sufficiently approach unity. However, we cannot argue in the same way with increases in relative populations. When per capita incomes are sufficiently similar, an increase in population in the poorer country may push the world economy out of a partial trade into a full trade equilibrium. However, when per capita endowments are very dissimilar, $L^P/L^R < 1/\tau^2$, the world economy remains trapped in a partial trade equilibrium even when relative population size $\mathcal{P}^P/\mathcal{P}^R$ goes to infinity. In this sense, the model predicts that per capita incomes are more important than population sizes in shaping patterns of

[14]The FP boundary is defined by $\omega(\mathcal{P}^P/\mathcal{P}^R)L^P/L^R = \tau$. From equation (3.5.1) we have $\omega' > 0$, which implies a negative relationship between $\mathcal{P}^P/\mathcal{P}^R$ and L^P/L^R.

Figure 3.5: relative per capita endowments vs. relative population sizes



international trade.

To consider the distinct impact of per capita income, we draw a dotted 'iso-size' line, i.e. the combination of relative per capita endowments and relative population sizes for which aggregate endowments of the two economies are identical, $L^P\mathcal{P}^P = L^R\mathcal{P}^R$. (Recall that, under CES preferences, such a situation would feature a world equilibrium with perfect symmetry). Since the iso-size line is flatter than the FP boundary, the two curves cross when L^P/L^R becomes sufficiently low. Hence two countries with identical aggregate endowments end up in partial trade when one country is rich but small and the other country is large but poor.

3.5.2 Welfare implications

When we allow populations to differ between the two countries, welfare implications remain qualitatively unchanged. In a *full trade* equilibrium, the welfare levels are

$$U^{i,f} = U^{i,f} = a\frac{\mathcal{P}^R L^R + \omega(\tau)\mathcal{P}^P L^P}{aF + \mathcal{P}^R + \tau\mathcal{P}^P}, \quad i = R, P$$

the same for both countries. Comparing full trade with autarky, it may be that the rich (rather than the poor) country gains more than the poor country. Welfare levels under autarky are $U^{i,a} = L^i / \left(F/\mathcal{P}^i + 1/a\right)$, $i = R, P$, which reveals that country-R households gain more from full trade when $L^P\mathcal{P}^P/(L^R\mathcal{P}^R) > (aF + \mathcal{P}^P)/(aF + \mathcal{P}^R)$. This situation arises when the rich country is very small so that access to the large world market generates a large gain in efficiency.

In a *partial trade* equilibrium we have

$$\begin{aligned} U^{P,p} &= a\frac{\left(\mathcal{P}^P + \tau\mathcal{P}^R\right) L^P}{aF + \tau\mathcal{P}^R + \mathcal{P}^P}, \text{ and} \\ U^{R,p} &= a\frac{\left(\mathcal{P}^P + \tau\mathcal{P}^R\right) L^P}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} + a\frac{\mathcal{P}^R\left(L^R - \omega(\tau)\tau L^P\right)}{aF + a\mathcal{P}^R}. \end{aligned}$$

It can be shown that $\partial U^{P,p}/\partial\tau > 0$ and $\partial U^{R,p}/\partial\tau < 0$. Hence, allowing for unequal population sizes does not change the welfare implications of a trade liberalization. When the world economy is in partial trade equilibrium, a trade liberalization improves welfare of country-R consumers but hurts consumers in country P. The reason is the same as above. In a partial trade equilibrium, a trade liberalization deteriorates terms of trade for the poor country. The higher relative price of imported goods implies that the consumption basket poor country consumers can afford becomes smaller. The preferred level of openness is $\tau = 1$ in the rich country and $\tilde{\tau} > 1$ in the poor country, where $\tilde{\tau}$ satisfies $\omega(\tilde{\tau})L^P/L^R = \tilde{\tau}$. Notice that $\tilde{\tau}$ is also the critical level of trade costs that lets the world economy switch from a full trade to a partial trade equilibrium.

3.6 Extensions

3.6.1 More than two countries

The above analysis examined the case of bilateral trade. In a two-country context, we demonstrated that per capita incomes have a crucial impact on trade patterns and that the impact of the aggregate size of an economy depends on whether size comes from per capita income or from population. We also showed that trade liberalizations (a reduction in trade costs) increase trade in a full trade equilibrium; but may *decrease* the volume of international trade in a partial trade equilibrium. One could argue that the latter result is an unattractive feature of our model.

3.6.1.1 Two rich and two poor countries

We show below that this result becomes much weaker or completely vanishes once we allow for more than two countries. To make the point, we consider the following interesting special case. Suppose there are four countries, identical in all dimensions except for their per capita endowments. Assume further that there are two rich countries, each of which has per capita endowment L^N, the "North"; and two poor countries with per capita endowment $L^S < L^N$, the "South". If $L^N/L^S < \tau$ there will be full trade, each country buys all domestically produced goods and imports all goods produced in all other countries. If $L^N/L^S > \tau$, however, there is partial trade. Partial trade now means that not all countries consume all goods, as the two poor (but not the two rich) countries consume only a subset of the global menu of goods. Denote by p^i and W^i the willingness to pay and the wage in country $i \in \{N, S\}$. Consider the partial trade equilibrium. The zero profit conditions become

$$2p^S\mathcal{P} + 2\tau p^S\mathcal{P} = \left(F + \frac{1+3\tau}{a}\mathcal{P}\right)W^i, \quad i = N, S$$

for goods that are traded between all four countries and

$$2p^N\mathcal{P} = \left(F + \frac{1+\tau}{a}\mathcal{P}\right)W^i$$

for goods that are traded only among the two rich countries. Exactly as in the two-country case, equal population sizes ensure factor price equalization, so we have $W^N = W^S = 1$. The resource constraints are

$$\begin{aligned} L^S\mathcal{P} &= N^S\left(F + \frac{1+3\tau}{a}\mathcal{P}\right) \text{ in type } S \text{ countries and} \\ L^N\mathcal{P} &= N_N^N\left(F + \frac{1+\tau}{a}\mathcal{P}\right) + N_T^N\left(F + \frac{1+3\tau}{a}\mathcal{P}\right) \text{ in type } N \text{ countries} \end{aligned}$$

where N^S is the range of goods produced in each S country; N_T^N is the range of goods supplied by firms in one of the N countries and traded worldwide; and N_N^N is the range of goods produced and traded only in the North. Since each Northern country imports all goods produced worldwide but each Southern country imports only a subset of these goods, the aggregate (regional) trade balance between North and South has to be balanced in equilibrium.[15] The value of aggregate Northern imports from the South are $2\tau p^S N^S$ and the value of aggregate Northern exports to the South are $2p^S N_T^N$ hence trade balance requires

$$\tau N^S = N_T^N.$$

Calculating the number of goods that are produced worldwide from the equations above is straightforward; it is equal to the level of welfare in the Northern country

$$U^N(\tau) = 2N^S + 2N_T^N + 2N_N^N = 2\frac{(1+\tau)\,L^S\mathcal{P}}{F + \frac{1+3\tau}{a}\mathcal{P}} + 2\frac{\left(L^N - \tau L^S\right)\mathcal{P}}{F + \frac{1+\tau}{a}\mathcal{P}}$$

From this equation, it can be shown that $\partial U^N(\tau)/\partial\tau < 0$, i.e. the welfare level of N-consumers increases as a result of a trade liberalization. Notice that, similar to the two-country case, this result arises because goods imported from the South become cheaper, creating demand for new goods. In the new equilibrium, more goods are produced and traded in the North. The deterioration (from the perspective of S countries) in the terms of trade leads to a situation where fewer goods are traded between the Northern and Southern world regions. This effect is similar to the two-country case. The increased threat of parallel trade induces Northern producers to withdraw their products from the world market and to sell their product exclusively in the rich Northern region.

[15] Due to the symmetry of our set-up, the volume of bilateral trade is undetermined. One of the Northern countries could produce predominantly (or exclusively) goods that are consumed only in the North while the other Northern country produces mainly (or exclusively) goods that are consumed worldwide. In that case, the first Northern country runs a trade surplus with the other Northern country and a trade deficit with both Southern countries taken together. Such trade imbalances cannot occur between the Southern countries, since each Southern country consumes all goods produced by the other Southern country, meaning that the South-South trade flows are of the same magnitude in either direction. However, each Southern country may run a surplus with one of the Northern countries that is balanced by a deficit with the other Northern country. Notice further that all bilateral trade flows are equalized in a full trade equilibrium. This is because all households in each country consume all goods that are produced worldwide.

The situation is somewhat different in the Southern countries. In particular, it may be that a trade liberalization also increases welfare in the South. We saw that the poorer country is strictly worse off as a result of lower trade costs in the two-country case. This need no longer be the case in the multi-country case. While North-South trade will unambiguously decrease due to a trade liberalization, lower trade costs will increase South-South trade. As a result, the impact of trade liberalizations on welfare in the South is unclear. To see this, calculate the welfare of the Southern consumer as

$$U^S(\tau) = 2N^S + 2N_T^N = 2\frac{(1+\tau)\, L^S \mathcal{P}}{F + \frac{1+3\tau}{a}\mathcal{P}}$$

from which $\partial U^S(\tau)/\partial\tau \leq 0$ follows when $aF/\mathcal{P} - 2 < 0$. The South is more likely to gain from lower trade costs if scale effects (lower $aF/\mathcal{P}$) grow in importance. A uniform global trade liberalization decreases N-S trade in this situation, but increased N-N and S-S trade dominate this effect in such a way that global trade increases, proving our initial claim.

3.6.1.2 Three unequal countries

Now consider the alternative interesting case with three equally large but unequally rich countries, R, M, and P. The differences in endowments between any bilateral combination of countries is sufficiently large such that $\min\{L_R/L_M, L_M/L_P\} > \tau$. This latter assumption implies that the threat of parallel trade exists in all bilateral trade flows. The equilibrium then takes the following structure. Households in country R consume all goods produced worldwide; households in country M consume only a subset of these goods; and households in country P an even smaller subset. There are three groups of firms: firms that sell worldwide, firms that sell in M and R, and firms that only sell in R. The latter producers set a price p^R that equals the willingness to pay of country R households. The second group of producers sets a price p^M in country M and τp^M in country R. The first group sets a price p^P in country P, and a price τp^P in countries M

and R. The zero profit conditions are given by [16]

$$\begin{aligned}\left(p^P + 2\tau p^P\right)\mathcal{P} &= W^i\left(F + \frac{1+2\tau}{a}\mathcal{P}\right) \quad i = P, M, R;\text{ sales worldwide} \qquad (3.6.1)\\ \left(p^M + \tau p^M\right)\mathcal{P} &= W^i\left(F + \frac{1+\tau}{a}\mathcal{P}\right) \quad i = M, R;\text{ sales in } M \text{ and } R\\ p^R\mathcal{P} &= W^R\left(F + \frac{1}{a}\mathcal{P}\right);\text{ sales in } R \text{ only.}\end{aligned}$$

Prices p^P, p^M and p^R can be directly calculated from the zero profit conditions. To ensure that we have $\tau p^P < p^M$ the modified trade condition

$$\frac{(1+2\tau)\left(\tau^2-1\right)}{\tau^2-\tau-1} < \frac{aF}{\mathcal{P}}$$

has to be satisfied. This condition is stronger than Assumption 1, hence $\tau p^M < p^R$ follows. This condition ensures that all possible bilateral trade flows are strictly positive in equilibrium.

From equation (3.6.1) it is clear that equal population guarantees equal wages (per efficiency unit of labor); this also holds in the three-country case. To see this, notice that country P exports to both country M and country R. To ensure balanced trade, either country M or country R (or both) export to country P. When both countries export to country P, the first zero-profit condition has to hold in all three countries, from which factor prize equalization follows immediately. The situation is similar when only country M but not country R exports to country P. Then the first zero-profit condition ensures factor price equalization between countries M and P. In that case the country R runs a trade deficit with country P which has to be offset by a surplus with country M. Ruling out the knife-edge case where country M exports only to country P but does export to country R, we conclude that there must be some goods country M exports to country R which establishes factor price equalization between M and R. Taken together, we have

[16] When specifying the zero-profit conditions, we have already implicitly assumed that goods are produced in a country that also consumes this good. In particular, goods that are consumed exclusively in country R are also produced in country R, and goods that are not consumed in country P are not produced in country P. This will be the case in equilibrium because equal population sizes lead to factor price equalization across the three countries $W^P = W^M = W^R$ and because larger profits margins (due to the absence of transport costs) let firms first serve the home market before selling abroad.

$W^P = W^M = W^R = 1$.

Solving the equilibrium is somewhat tedious but straightforward. Using resource constraints and the trade balance conditions between each country and the rest of the world yields the following utility levels in the three countries (see Appendix)

$$\begin{aligned}
U^P(\tau) &= \frac{1+2\tau}{F+\frac{1+2\tau}{a}\mathcal{P}}L^P\mathcal{P} \\
U^M(\tau) &= \frac{1+2\tau}{F+\frac{1+2\tau}{a}\mathcal{P}}L^P\mathcal{P}+\frac{(1+\tau)\left(L^M/L^P-\tau\right)}{F+\frac{1+\tau}{a}\mathcal{P}}L^P\mathcal{P} \\
U^R(\tau) &= \frac{1+2\tau}{F+\frac{1+2\tau}{a}\mathcal{P}}L^P\mathcal{P}+\frac{(1+\tau)\left(L^M/L^P-\tau\right)}{F+\frac{1+\tau}{a}\mathcal{P}}L^P\mathcal{P} \\
&\quad +\frac{L^R/L^P-\tau L^M/L^P+\tau-\tau^2}{F+\frac{1}{a}\mathcal{P}}L^P\mathcal{P}
\end{aligned}$$

These results allow us to determine the level of welfare in the three countries.

Proposition 3. *In a three country model with sufficient endowment differences across countries, $L_R > \tau L_M > \tau^2 L_P$, and sufficiently low trade costs so that the modified trade condition $(1+2\tau)(\tau^2-1)/(\tau^2-\tau-1) < aF/\mathcal{P}$ holds, the poor (rich) country loses (gains) from a trade liberalization (lower τ). The middle income country gains from a trade liberalization if L^M/L^P is not too large.*

Proof. Clearly, we have $\partial U^P(\tau)/\partial\tau > 0$. We check the sign of the derivative $\partial U^M(\tau)/\partial\tau$.

$$\begin{aligned}
\frac{\partial U^M(\tau)}{\partial\tau} &= L^P\mathcal{P}\frac{2F}{\left[F+\frac{1+2\tau}{a}\mathcal{P}\right]^2}-L^P\mathcal{P}\frac{2F}{\left[F+\frac{1+\tau}{a}\mathcal{P}\right]^2} \\
&\quad +L^P\mathcal{P}\frac{\left[L^M/L^P+1-2\tau\right]F-\frac{(1+\tau)^2}{a}\mathcal{P}}{\left[F+\frac{1+\tau}{a}\mathcal{P}\right]^2} < 0
\end{aligned}$$

if and only if

$$\frac{\left[F+\frac{1+\tau}{a}\mathcal{P}\right]^2}{\left[F+\frac{1+2\tau}{a}\mathcal{P}\right]^2} < \frac{-\left(L^M/L^P-\tau\right)F+(1+\tau)\left(F+\frac{(1+\tau)}{a}\mathcal{P}\right)}{2F}.$$

In the special case $L^M/L^P = \tau$ the inequality becomes $\frac{\left[F+\frac{1+\tau}{a}\mathcal{P}\right]^2}{\left[F+\frac{1+2\tau}{a}\mathcal{P}\right]^2} < \frac{(1+\tau)(F+\frac{(1+\tau)}{a}\mathcal{P})}{2F}$. Hence, when L^M/L^P is not too large, the middle income country will gain.

Finally, $\partial\left[U^P(\tau)\mathcal{P}+U^M(\tau)\mathcal{P}+U^R(\tau)\mathcal{P}\right]/\partial\tau<0$. As $\partial N_R^R/\partial\tau<0$, we must have $\partial U^R(\tau)/\partial\tau<\partial U^M(\tau)/\partial\tau$. Hence, $\partial U^R(\tau)/\partial\tau<0$ whenever $\partial U^P(\tau)/\partial\tau>0$. □

If L^P is sufficiently above zero, the middle income country gains from lower trade costs. As in the two-country case, changes in the terms of trade drive the results. The terms of trade improve for the rich country, both for trade with country P and country M. This improves the welfare of country R consumers. The terms of trade deteriorate for the poor country, both for trade with country M and country R. The situation is ambiguous for the middle income country. Here terms of trade improve against the poor country but deteriorate against the rich country. Hence it is not a prior clear whether country M will gain or lose. If the majority of goods is imported from the poor country, overall terms of trade will improve. In contrast, if the majority of goods is imported from rich country, overall terms of trade will deteriorate. The terms of trade effect will be negative if country P is very poor (and hence L^M/L^P large). In that case, the improvement in terms of trade with the poor country is negligible because the range of goods that can be imported from country P is small, and most goods will be imported from country R, with which the terms of trade deteriorate.

3.6.2 Heterogeneous trade costs

Another reason why the effect of trade liberalizations on volumes may be less clear are heterogeneous trade costs. For clarity, we go back to the case of two countries that are symmetric in all dimensions except for per capita endowments. Assume there are two product types, type 0 has low trade costs τ_0 and type 1 has high trade costs $\tau_1>\tau_0$, but $\tau_1\leq\sqrt{aF/\mathcal{P}+1}$ still holds. To keep things simple, we assume that a firm does not learn of the type of its product until the fixed setup investment has been made.[17] More precisely, a firm comes up with a product of type 0 with probability π, and type 1 with probability $1-\pi$. Assume further that firms can insure themselves perfectly against high-cost realizations, meaning that all firms make zero profits in equilibrium.

[17]This formulation avoids a situation where firms with low transport costs make positive profits in equilibrium. Allowing for profits would complicate the analysis but would not yield any substantial additional insights.

The interesting case is when the threat of parallel trade restricts firms of type 0 (low trade cost) in their price-setting, while this does not apply to firms of type 1 (high trade cost). In that case, there will be partial trade in low-cost varieties but full trade in high-cost varieties, and we have $p_{0T}^R/p_0^P = \tau_0$ and $p_1^R/p_1^P < \tau_1$. Notice that, since high-cost and low-cost varieties yield the same utility, the prices of these goods do not differ by type, $p_1^P = p_0^P = p^P$ and $p_1^R = p_{0N}^R = p^R$. Denote by $E\tau \equiv \pi\tau_0 + (1-\pi)\,\tau_1$ the expected trade cost, and by $Ep^R \equiv \pi\tau_0 p^P + (1-\pi)\,p^R$ the expected price that an internationally active producer can charge in the rich country. The zero-profit condition of internationally active firms and of exclusive country-R producers now becomes

$$\begin{aligned}(Ep^R + p^P)\mathcal{P} &= W^i\left[F + \frac{\mathcal{P}\,(1+E\tau)}{a}\right] \text{ and} &(3.6.2)\\ p^R\mathcal{P} &= W^R\left[F + \frac{\mathcal{P}}{a}\right]. &(3.6.3)\end{aligned}$$

When producers of type 1 do not face a pricing constraint, while producers of type 0 do, the equilibrium has the following structure. All type 1 goods are traded internationally, while type 0 goods are only partially traded. This means country R produces πN^R goods of type 0 and $(1-\pi)\,N^R$ goods of type 1. The situation is analogous for country P.

The resource constraints for the two countries are now

$$\begin{aligned}L^R\mathcal{P} &= N_T^R\left(F + \frac{\mathcal{P}\,(1+E\tau)}{a}\right) + N_N^R\left(F + \frac{\mathcal{P}}{a}\right) &(3.6.4)\\ L^P\mathcal{P} &= N^P\left(F + \frac{\mathcal{P}\,(1+E\tau)}{a}\right). &(3.6.5)\end{aligned}$$

Finally, the balance of payments condition is given by

$$N^P Ep^R = N_T^R p^P. \tag{3.6.6}$$

Equations (3.6.2) - (3.6.6) constitute a system of 6 equations in 7 unknowns: p^R, p^P, W^R, W^P, N^P, N_T^R, and N_N^R. We get the seventh equation by the choice of the numéraire $W^R = 1$.

We can solve for the general equilibrium in this regime and calculate welfare levels. An examination of the welfare level of country P – which is simply the sum of the worldwide traded varieties – suffices for checking the impact of a trade liberalization. This yields

$$U^P = N^P + N_T^R = a \frac{(1 + \tau_1 (1 - \pi)) \mathcal{P}}{aF (1 - \pi) + ((1 - \pi) + \pi \tau_0 + (1 - \pi) \tau_1) \mathcal{P}} L^P.$$

It is straightforward to check that $\partial U^P / \partial \tau_0 < 0$ whereas $\partial U^P / \partial \tau_1 > 0$. Hence whether a trade liberalization has a positive or a negative impact on the number of internationally traded varieties is ambiguous and depends on the relative importance of the types of goods constrained in price setting. When the proportion of high-trade cost products $(1 - \pi)$ is sufficiently large, a general trade liberalization (a simultaneous reduction in τ_0 and τ_1) will increase the extensive margin of international trade.

3.6.3 National versus international exhaustion rules

Up to now we were working under the assumption of unrestricted parallel trade. The implicit assumption in the equilibria presented above was that there is "international exhaustion". This means that the intellectual property owner (i.e. a patent-, copyright-, and/or trademark-holder) loses its control of commercial exploitation when the product is sold on the national or international market. Hence, international arbitrageurs force firms to restrict their international price schedules to deter parallel trade. In many countries, however, parallel trade is restricted by law. For instance, the US applies "national exhaustion", meaning that a producer's patent or copyright expires when it is sold on the home market but not when sold on the international market. Similarly, the EU applies "regional exhaustion" which allows parallel trades only within the EU area. Parallel imports are restricted under national or regional exhaustion.

By introducing a new policy parameter we now investigate the role of exhaustion rules. Assume that ex ante there is an exogenous probability π that parallel trade is legally restricted for a particular good. Think of π as representing the share of industries for which "national exhaustion" applies (alternatively we can think of a world with "national exhaustion" rules, but the enforcement of these rules is uncertain. π then represents the probability that the rules are actually enforced). Firms learn only after paying the fixed costs F whether their product is subject to parallel trade. To keep things simple, we go back to the case where both countries have the same population sizes $\mathcal{P}^R = \mathcal{P}^P = \mathcal{P}$, so that we have wage equalization $W^R = W^P = 1$. The zero profit conditions of internationally active and domestic firms, respectively, become

$$Ep\mathcal{P} = F + \frac{(1+\tau)\mathcal{P}}{a} \text{ and } p^R\mathcal{P} = F + \frac{\mathcal{P}}{a}$$

where an internationally active firm's expected sales are given by $Ep\mathcal{P} \equiv \pi\left(p^P + p^R\right)\mathcal{P} + (1-\pi)\left(p^P + \tau p^P\right)\mathcal{P}$. (Notice that we implicitly assume that firms can perfectly insure themselves against low-price realizations in the case when no parallel trade restrictions apply. This assumption keeps things simple because it means that all firms make zero profits in equilibrium.) Using the zero-profit conditions of internationally active producers, we can solve for the price in the poor country

$$p^P = \frac{1}{1+\tau-\pi\tau}\left(\frac{F}{\mathcal{P}} + \frac{1+\tau}{a} - \pi\left(\frac{F}{\mathcal{P}} + \frac{1}{a}\right)\right).$$

Using Assumption 1, it is easy to show that stricter enforcement of parallel import restrictions or, equally, a higher share of products with "national exhaustion" rules (both represented by a higher π) is associated with lower prices p^P for internationally traded products in the poor country. The reason is that a higher π increases the incentive for rich-country firms to trade internationally. This generates a pro-competitive effect reducing prices in the poor country and thus increasing the welfare of the households there. The welfare of the rich country households falls. To see this, notice that the number of goods produced in the poor country is still given by equation (3.4.2) which does not depend on π. Using the budget constraint of poor consumers $L^P = p^P(N^P + N_T^R)$ lets us calculate

$$\frac{\partial N_T^R}{\partial \pi} = \frac{\partial N_T^R}{\partial p^P}\frac{\partial p^P}{\partial \pi} > 0$$

Since the number of goods produced in the poor country remains unchanged, welfare of households in the poor country increases. The pro-competitive effect on price in the poor country implies that poor consumers can afford more goods, improving their welfare. The opposite is true for the rich country. As the higher π induces more rich country firms to trade internationally, a larger fraction of resources is devoted to the production of these internationally traded goods. Hence a smaller range of goods is produced in the rich country and the total number of goods produced worldwide goes down. This establishes that welfare of rich-country consumers falls.

The effect of trade liberalizations (lower τ) on trade is now ambiguous. To see this consider first the case of "national exhaustion", i.e. $\pi = 1$. In such a situation producers can perfectly price discriminate between countries and hence a full trade equilibrium always prevails. Lower trade costs simply free resources to produce additional varieties. As all these additional varieties will be traded, trade will increase as a reaction to the liberalization. We have seen above that the converse holds for "international exhaustion", $\pi = 0$. Thus, in general the effect of a trade liberalization depends on the share of products with "national exhaustion" rules π, with positive effects more likely the closer π is to one.

3.6.4 Within-country inequality

Non-homotheticities not only generate important effects of per capita endowments on trade, they also imply that within-country inequality may shape trade patterns in an important way. In our context, the case of within-country inequality can be best understood as a special case of a multi-country model, where the trade costs between some countries are zero. Between these countries, the parallel trade restrictions would immediately become binding as long as there is a slight difference in per capita endowments. In other words, with inequality within countries we always have some degree of exclusion, meaning that some firms will only sell to the rich charging a high price while other firms will sell to all consumers.

We highlight the role of inequality by looking at the most simple case of two identical countries that are both populated by rich and poor households. This simple example shows which mechanisms are present in the more general cases. In particular, we demonstrate that the threat of parallel trade under within country inequality affects trade patterns even when countries are completely symmetric.

3.6.4.1 Low trade costs

We assume that β percent of the population in every country are poor owning an endowment of $\theta L < L$ and that the remaining $1-\beta$ percent of the population are rich and own an endowment $[(1-\beta\theta)/(1-\beta)]\, L > 1$ (hence per capita endowment is still L). We index rich and poor households by r and p, respectively. Let us first consider the case when trade costs are low. In a fully integrated market when $\tau = 1$ there are two group of firms: "mass producers" selling to all consumers in both countries and "exclusive producers" selling only to the rich in both countries. In fact, this equilibrium holds true for small values of τ such that the scope for price discrimination between countries is limited. By symmetry, we have factor price equalization and set $W = 1$. Using countries' resource-constraints, firms' zero-profit and households' budget constraints,[18] it is straightforward to calculate the number of products, N^p and N^r, sold to everyone and to the rich, respectively, as

$$N^p = \frac{\theta a L}{aF/\mathcal{P} + 1 + \tau} \text{ and } N^r = \frac{(1-\theta)aL}{aF/\mathcal{P} + (1+\tau)(1-\beta)}.$$

It is straightforward to study the impact of a trade liberalization. Using $U^p = N^p$ and $U^r = N^p + N^r$ it follows that both rich and poor consumers gain from a trade liberalization. While the rich gain more in absolute terms, the poor gain more in relative terms. Hence a trade liberalization even reduces consumption inequality $N^p/(N^r + N^p)$. This result generalizes to the case of more types of consumers. Notice that this is quite different from inequalities across countries where we saw that a fall in trade costs helps the richer but hurts poorer households.

[18]The resource constraint is given by $L\mathcal{P} = N^p\left[F + (1+\tau)\mathcal{P}/a\right] + N^r\left[F + (1-\beta)(1+\tau)\mathcal{P}/a\right]$ in both countries, the zero-profit conditions are $2p^p\mathcal{P} = F + (1+\tau)\mathcal{P}/a$ for firms that sell to all households worldwide and $2(1-\beta)p^r\mathcal{P} = F + (1-\beta)(1+\tau)\mathcal{P}/a$ for firms that sell only to rich households in both countries. Rich households' budget constraints are given by $[(1-\beta\theta)/(1-\beta)]\, L = 2p^rN^r + 2p^pN^p$in both countries, and poor households' budget constraints are $\theta L = 2p^pN^p$.

3.6.4.2 High trade costs

The above equilibrium arises if trade costs are sufficiently small. When trade costs are higher, an equilibrium with exclusive producers selling only to rich consumers and mass producers selling to all consumers worldwide no longer exists. The reason is that high trade costs make a new strategy attractive: sell to all consumers at home and only to rich consumers abroad. In the Appendix we show that, depending on the extent of within-country inequality, either of two different equilibrium scenarios will emerge. If inequality is high, the equilibrium is characterized by some firms selling only to rich consumers in both countries while other firms follow a "separating" strategy: selling to both types of households in the home market; and only to the rich on the foreign market. With high within-country inequality, these strategies yield zero profit in equilibrium; and they strictly dominate the strategy of selling to rich and poor consumers in both markets.

In contrast, if inequality is low and trade costs are high, the equilibrium is characterized by the co-existence of firms selling to all households worldwide and firms selling to all consumer on the home market and to rich consumers on the foreign market. The exclusive strategy, i.e. selling only to the rich on both markets is not a profitable option. We find that trade liberalizations increase welfare for both types of consumers. The results that, in relative terms, the poor gain more than the rich from a trade liberalization continues to hold.

3.7 More general preferences

We assumed 0-1 preferences in the analysis above. On the one hand, this assumption yields a framework that is highly tractable and generates closed-form solutions. On the other hand, this assumption restricts households' adjustments to the extensive margin. The standard CES case with all adjustments happening on the intensive margin and our 0-1 case should thus be understood as two polar cases. We go beyond these polar cases in this Section and introduce more general preferences that allow for adjustments on both margins. In particular, we will show that the qualitative characteristics of the equilibria we obtained with 0-1 preferences carry over to the case of more general preferences featuring both non-trivial intensive *and* extensive margins.

We take up the analysis of Section 3.4 where we study two equally large, but unequally rich countries. Within countries, households are identical. Trade patterns are therefore shaped by differences in per capita endowments across countries. Now replace 0-1 preferences by the following general utility function

$$U = \int_0^\infty v(c(j))dj,$$

where $c(j)$ denotes the consumed quantity of good j. It is assumed that the subutility $v()$ satisfies $v' > 0$, $v'' < 0$ and $v(0) = 0$. Beyond these standard assumptions on $v()$, we make two further crucial assumptions: (i) $v'(0) < \infty$ and (ii) $-v'(c)/[v''(c)c]$ is decreasing in c. The former assumption implies that reservation prices are finite and there is therefore a non-trivial extensive margin of consumption; the latter assumption implies that the price elasticity of demand is decreasing along the demand curve. Notice that monopolistic pricing implies $p = (1 + v'(c)/[v''(c)c])^{-1}W/a$. To ease notation, we denote by $\mu(c) \equiv (1 + cv''(c)/v'(c))^{-1}$ a monopolistic firm's mark-up. Since $-v'(c)/[v''(c)c]$ is decreasing in c, we have $\mu'(c) > 0$.

It is straightforward to see that finite reservation prices again make an autarky equilibrium possible. To ensure that there will be trade, we have to adjust the trade condition of Assumption 1 as follows

Proposition 4. *Denote by c_a^R consumption per variety under autarky in the rich country. If trade costs are sufficiently small $\tau < \mu(c_a^R)v'(0)/v'(c_a^R)$ where $aF/\mathcal{P} = c_a^R(\mu(c_a^R) - 1)$, trade occurs in equilibrium.*

Proof. The proof is based on the same tenet as in Section 3.3 above. We determine the autarky equilibrium and ask under which conditions an entrepreneur has incentives to sell his products abroad. Setting $W = 1$, optimal monopolistic pricing implies $p = \mu(c)/a$.

With free entry, profits $\mathcal{P}(p_a^R - 1/a)c_a^R$ must equal set up costs F

$$aF/\mathcal{P} = \left(\mu(c_a^R) - 1\right) c_a^R \tag{3.7.1}$$

The equilibrium is symmetric for all firms, hence the resource constraint reads

$$L^R = N_a^R \left(F + \mathcal{P}c_a^R/a\right) \tag{3.7.2}$$

Solving (3.7.1) and (3.7.2) for c_a^R and N_a^R, we see that c_a^R does not depend on L^R. Hence when the two countries differ only in L^i but have equal populations, intensive consumption levels under autarky are identical between the two countries, $c_a^R = c_a^P$. Selling one marginal unit abroad at price $v'(0)/\lambda_a^P$, allows the purchase of $v'(0)/(\lambda_a^P p_a^P)$ foreign goods. Since $\lambda_a^P = v'(c_a^P)/p_a^P$ and $c_a^R = c_a^P$ this is equal to $v'(0)/v'(c_a^R) > 1$. Reselling this (new) product at home, yields a price $v'(0)p_a^R/v'(c_a^R)$ minus trade costs. Hence, this strategy is profitable if $\left[v'(0)p_a^R/v'(c_a^R)\right] \cdot \left[v'(0)/v'(c_a^R)\right] > \tau^2$. Expressing p_a^R in terms of c_a^R, we get the condition of the Proposition. □

We are now able to discuss the *full trade* regime. Let us start from a full trade equilibrium where differences in per capita endowment L^P/L^R are sufficiently close to unity, so that firms do not face a threat of parallel trade. We denote the optimal price of a country-R firm on its home market by p_R^R and the corresponding price in country P by p_R^P. Monopoly pricing implies $p_R^R = \mu(c_R^R)/a$ and $p_R^P = \mu(c_R^P)\tau/a$, respectively. The firm does not face any threat of parallel trade if $p_R^R/p_R^P \leq \tau$, or if

$$\frac{\mu(c_R^R)}{\mu(c_R^P)} \leq \tau^2. \tag{3.7.3}$$

This is a sufficient condition for the existence of a full trade equilibrium.

Let us now consider the existence of a *partial trade* equilibrium. A necessary condition for such an equilibrium is that condition (3.7.3) is violated. This condition may be violated either if τ is close to unity, or if consumption levels c_R^R and c_R^P diverge strongly (recall that $\mu'(c) > 0$ and $\mu(0) = 1$).[19] If L^P approaches zero, c_R^P approaches zero as well, and the denominator in equation (3.7.3) approaches unity. There is thus a level of trade cost τ sufficiently close to unity and/or a country-P endowment L^P sufficiently small, so that we get $\mu(c_R^R) > \tau^2\mu(c_R^P)$.

When the inequality in (3.7.3) is violated, exporting firms will set prices $p_R^R/p_R^P = \tau$ to prevent parallel trade. Notice, however, that violation of condition (3.7.3) does not necessarily imply a partial trade equilibrium. The reason is that there is adjustment both along the extensive margin and along the intensive margin. Even when condition (3.7.3) is violated, all goods may be traded as country-P households may still consume all goods produced worldwide, but in lower quantities. In other words, violation of the condition (3.7.3) is necessary but not sufficient for a partial trade equilibrium.

To show under which conditions country-P households will not consume all goods produced worldwide, we need to look at incentives of country-R firms to sell their products exclusively to rich domestic consumers. The profit of a country R producer is given as follows (to ease notation let us write $p_R^R \equiv \tau p$ and $p_R^P \equiv p$)

$$\pi = \mathcal{P}\left(\tau p - 1/a\right) c_R^R + \mathcal{P}\left(p - \tau/a\right) c_R^P.$$

The demand curve of country-R consumers is given by $v'(c_R^R) = \lambda^R \tau p$ and the corresponding demand curve of country-P consumers is $v'(c_R^P) = \lambda^P p$. Hence we have, $dc_R^R/dp = (1/p)v'(c_R^R)/v''(c_R^R)$ and $dc_R^P/dp = (1/p)v'(c_R^P)/v''(c_R^P)$. The first order condition of the monopolistic firm's price setting choice is given by

$$\frac{\tau p - 1/a}{\tau p}\left(-\frac{v'(c_R^R)}{v''(c_R^R)}\right) + \frac{p - \tau/a}{p}\left(-\frac{v'(c_R^P)}{v''(c_R^P)}\right) = \tau c_R^R + c_R^P.$$

To examine whether a partial trade equilibrium exists, let L^P and therefore c_R^P approach zero. The first order condition then becomes

[19] By d'Hôpital's rule, noting that $v(0) = 0$ and $v'(0)$ finite, $\lim_{c\to 0} v'(c)c/v(c) = \lim_{c\to 0} 1 + v''(c)c/v'(c)$. However, $\lim_{c\to 0} v'(c)c/v(c) = v'(0)\cdot\lim_{c\to 0} c/v(c) = v'(0)/v'(0) = 1$. This implies $\lim_{c\to 0} v''(c)c/v'(c) = 0$ and $\lim_{c\to 0}\mu(c) = 1$.

$$\frac{\tau p - 1/a}{\tau^2 p}\left(-\frac{v'(c_R^R)}{v''(c_R^R)c_R^R}\right) + \frac{p - \tau/a}{\tau p c_R^R}\left(-\lim_{c_R^P \to 0}\frac{v'(c_R^P)}{v''(c_R^P)}\right) = 1 \tag{3.7.4}$$

Now consider the optimal decision of a country-R firm which decides to produce for domestic consumers only. Denoting by p^N and c_R^N price and quantity of non-traded goods, the first order condition for exclusive producers is

$$\frac{p^N - 1/a}{p^N}\left(-\frac{v'(c_R^N)}{v''(c_R^N)c_R^N}\right) = 1. \tag{3.7.5}$$

We now compare equations (3.7.4) and (3.7.5) for the case where τ is sufficiently close to 1 such that $p > \tau/a$. If $v'(0)/v''(0)$ is larger than zero - which is fulfilled if $v''(0)$ is finite - the price of a non-exporting firm p^N is strictly larger than the price of an exporting firm τp. Since $c_R^P \to 0$ when $L^P \to 0$, export revenues are zero, hence profits of the non-exporting firm must be higher because it sets the profit maximizing price $p^N > \tau p$. This implies that an outcome where all firms export cannot be an equilibrium – provided that L^P is sufficiently close to zero and τ is sufficiently close to one. We summarize our discussion in

Proposition 5. *If $v''(0)$ is finite, a partial trade equilibrium always exists.*

Proof. In text. □

3.8 Conclusions

This chapter incorporates non-homothetic preferences into a standard "new" trade theory framework. We propose modeling non-homotheticities by indivisible consumer goods that are either consumed in unit quantity or not consumed at all. Such a specification implies that consumer choice is along the extensive margin whereas a choice along the intensive margin of consumption is ruled out by assumption. This is orthogonal to the standard CES-framework where households have infinite reservation prices and the allocation of expenditures relates solely to the intensive margin of consumption.

We elaborate the *role of per capita incomes* in international trade patterns which, for given aggregate output, is absent in any homothetic model of international trade. Consider two countries with the same aggregate endowment, one country is small and rich and the other country is large and poor. Our model predicts that large differences in per capita endowments lead to a partial world trade equilibrium in which many goods produced in the rich country will not be traded and consumed in the poor country, while all goods produced in the poor country will be traded and consumed in the rich country. In contrast, when differences in per capita endowments are small, a full trade equilibrium emerges. In such an equilibrium, all goods produced in the two countries are traded internationally and consumed in both countries. Hence our model features the famous Linder hypothesis according to which countries that are more similar in per capita endowments trade more intensively with one another.

Our analysis provides us with a simple general equilibrium framework of *parallel trade*. The partial world trade equilibrium emerges when inequality across countries is high so that differences across countries in consumers' willingness to pay for differentiated products are very large. In that case, the threat of parallel trade limits the scope of price setting in the rich country. This is because arbitrage traders can purchase the good cheaply in the poor country, ship it back and underbid local producers in the rich country. To inhibit such parallel trade, internationally active firms have to set low prices in the rich country. In equilibrium, firms in the rich country are indifferent between selling their product on the world market and selling their product only on the home market. The general equilibrium perspective of our model makes the fraction of internationally active firms endogenous. This effect is typically not considered in partial equilibrium settings of parallel trade but has a potentially important impact on trade patterns.

Concerning the welfare effects of trade, we find that a trade liberalization (a reduction in iceberg trade costs) increases welfare of consumers in both countries when the world economy is in a full trade equilibrium, but hurts the poor country (and benefits the rich country) when the world economy is in a partial trade equilibrium. The reason for the latter result is that exporters of the poor country need to reduce prices of traded goods in the rich country to inhibit parallel trade, while exporters of the rich country have no such restrictions in the poor country. Consumers in the rich country face decreasing prices, and consumers in the poor country are confronted with a lower range of import goods because higher competition on the world market induces rich-country firms to concentrate their sales exclusively on the home market.

While our analysis is made under very specific assumptions, our model is simple enough to be extended in several directions. We extended our set-up to more than two countries, to heterogeneous trade costs, to commercial policies, and to within-country inequality. Finally, we showed that partial trade equilibria emerge for a broad class of more general preferences.

Our model is complementary to existing supply side approaches and potentially helpful in understanding the dynamics of world trade patterns that arise due to major changes in the distribution of world purchasing power. This is particularly relevant in the case of large emerging markets such as China, India, Brazil, etc. that have experienced high growth in per capita incomes over the past decades. From an empirical point of view, disentangling the demand effects emphasized in this chapter from the supply/technology factors emphasized in the standard model is of particular interest.

3.A Appendix

3.A.1 High trade costs: the equilibrium when assumption 1 does not hold

We discuss the outcome when trade costs are so high such that assumption 1 does not hold, $\tau > \sqrt{aF/\mathcal{P}+1}$. We will see that this case is characterized by multiple equilibria.

From our discussion in Section 3.4.1 we know that full trade is an equilibrium if $p^* > \tau W/a$ (where p^* is the price on the foreign market under full trade). We use equation 3.4.1 in the text to get

$$\frac{L^*}{L+L^*}\frac{aF+(1+\tau)\mathcal{P}}{a\mathcal{P}} > \tau/a \tag{3.A.1}$$
$$\frac{L^*}{L} > \frac{\tau}{aF/\mathcal{P}+1} \tag{3.A.2}$$

where $W=1$ is again chosen as numéraire.

This condition is more likely to be fulfilled when countries are less different, L^*/L close to one, which is intuitive. Note that for higher setup costs F the trade condition is ceteris paribus more likely to hold, which reflects the fact that high fixed costs make trade more beneficial. Further, full trade becomes less likely when trade costs τ increase. (Eventually, when τ exceed $aF/\mathcal{P}+1$, full trade will not be an equilibrium, even when the countries are symmetric. This confirms our discussion in Section 3.3).

When the foreign country gets poorer, L^*/L becomes smaller, the foreign country price p^* eventually falls short of $\tau W/a$ and condition (3.A.1) is reversed. In that case, the foreign consumers buying all goods cannot constitute an equilibrium any more. Because of the discrete nature of 0-1 preferences, the number of products consumed adjusts such that their willingness to pay is just sufficient to cover the production and trade costs, i.e. $p^* = W\tau/a$. In this case, obviously, home firms are indifferent whether to export or sell at home only. In equilibrium, N_T firms trade and $N-N_T$ firms sell at home only whereas all foreign firms export. Hence, this equilibrium looks in some way similar to the partial trade regime. The reason for "partial" trade is not the price differential but the mere size of the willingness to pay. It should be noted, however, that this outcome is restricted to 0-1 preferences and not robust to more general preferences as discussed in the previous Section. With continuous preferences all products are exported albeit at a low quantity, as long as trade costs are below the autarky level. In the general case, partial trade equilibria only occur when the price differential constraint $p/p^* \leq \tau$ to prevent parallel imports is binding.

The mass of exporters N_T can be determined from the balance of payments condition $p^* N_T = pN^*$. Note that $p^* = \tau/a$ and $p = (aF + \mathcal{P})/(a\mathcal{P})$, where the latter equation follows from the zero profit condition $(p + p^*)\mathcal{P} = F + (1+\tau)\mathcal{P}/a$. Besides, we see that the price differential constraint $p/p^* \leq \tau$ holds, as $\tau > \sqrt{aF/\mathcal{P}+1}$ in the high trade costs regime. Using the resource constraints $L = N(F + (1 + \varphi\tau N_T/N)\mathcal{P}/a)$ and $L^* = N^*(F + (1+\tau)\mathcal{P}/a)$ and we note that $p^* = \tau/a$ and $p = (aF + \mathcal{P})/(a\mathcal{P})$. We get

$$\frac{N_T}{N} = \frac{aF/\mathcal{P}+1}{\tau} \frac{L^*/L}{1 + \frac{\tau}{aF/\mathcal{P}+1} - L^*/L}.$$

We see that the share of exporters N_T/N is monotonically increasing in L^*/L and approaches 1 at $L^*/L = \tau/(aF/\mathcal{P}+1)$.

Having characterized the trade equilibria for all parameter combinations $(\tau, L^*/L)$, there is one important aspect left. With high trade costs, $aF/\mathcal{P} + 1 > \tau > \sqrt{aF/\mathcal{P}+1}$, there are multiple equilibria. The reason is the following: autarky is a Nash equilibrium in that case. The argument follows the same lines as the derivation of assumption 1: If a country is in autarky, a single entrepreneur will not find it worthwhile to export as he will incur losses from doing so: $p < \tau^2 W/a$.

The multiplicity of equilibria arises because the individual firms cannot coordinate their actions. If countries are in autarky, there exists no clearing of balances at the border. Therefore a single firm has to export and then import at the same time (which gives rise to the τ^2 term in the inequality $p < \tau^2 W/a$. [20] Finally, note that the trade

[20]This is also the reason why there are only two equilibria, not three. As soon a small but positive measure of firms is trading a foreign exchange market through the balance of payment exists. Hence, export revenues discretely jump up a soon as a positive measure of firms is engaged in international affairs. This discontinuity precludes the existence of an "intermediate" second equilibrium.

equilibria are always pareto superior to the autarky equilibrium as long as $\tau < aF/\mathcal{P}+1$.

Finally, we analyze what happens if Assumption 1 is satisfied in only one country (and violated in another country e.g. because its $\mathcal{P}$ is very small). Obviously, the country for which the trade condition holds starts doing these trade and thus creates a foreign exchange market. Thus trade now needs not to overcome τ twice, but only once. Therefore, if for the foreign country $\tau < aF/\mathcal{P}^*+1$ we will swich to a normal trade equilibrium (i.e. the trade condition $\tau < \sqrt{aF/\mathcal{P}+1}$ has to hold for one country only). If on the other hand $\tau \geq aF/\mathcal{P}^*+1$ the home country will go on shipping goods back and forth, but the tiny foreign country producers do not engage in international trade - they sell their goods to local consumers and foreign firms, but do not export their goods on their own. Some consumers in this country will consume the foreign varieties and some the home varieties, but the measure of varieties is the same as under autarky.

3.A.2 Details: three unequal countries

In equilibrium, the current account of each with the rest of the world has to be equalized. Denoting by N_j^i the imports of country j from country i, balanced trade implies

$$\begin{aligned}
2\tau p^P N_P^M &= p^P \left(N_P^M + N_P^R\right) \text{ for country } P \\
(1+\tau)p^P N_P^M + \tau p^M N_R^M &= p^M N_M^R + \tau p^P \left(N_M^P + N_M^R\right) \text{ for country } M \\
(1+\tau)p^P N_P^R + p^M N_M^R &= \tau p^M N_R^M + \tau p^P \left(N_R^P + N_R^M\right) \text{ for country } R
\end{aligned}$$

Note that we have 5 linearly independent equations and 6 unknowns (the prices p^i, $i \in \{P, M, R\}$ are determined by the zero profit conditions). Hence, it is only possible to determine the sum of $\left(N_P^M + N_P^R\right)$. Because of this indeterminacy we are free to consider the case where all bilateral trade flows are balanced.[21] Then we have

$$\tau N_P^P = N_P^M = N_P^R \text{ and } \tau N_M^M = N_M^R.$$

[21] Notice that countries M and R consume all goods produced in country P; and country R consumes all goods produced in country M.

Using the resource constraints we may calculate the goods produced in the three countries

$$
\begin{aligned}
N_P^P &= \frac{L^P\mathcal{P}}{F+\frac{1+2\tau}{a}\mathcal{P}}, \quad N_P^M = \frac{\tau L^P\mathcal{P}}{F+\frac{1+2\tau}{a}\mathcal{P}}, \quad N_P^R = \frac{\tau L^P\mathcal{P}}{F+\frac{1+2\tau}{a}\mathcal{P}} \\
N_M^M &= \frac{\left(L^M-\tau L^P\right)\mathcal{P}}{F+\frac{1+\tau}{a}\mathcal{P}} \quad N_M^R = \frac{\tau\left(L^M-\tau L^P\right)\mathcal{P}}{F+\frac{1+\tau}{a}\mathcal{P}} \\
N_R^R &= \frac{\left[L^R-\tau L^M-\tau(\tau-1)L^P\right]\mathcal{P}}{F+\frac{1}{a}\mathcal{P}}.
\end{aligned}
$$

3.A.3 Details: within-country inequality with high trade costs

We discuss equilibria under within-country inequality and high trade costs. With high trade costs, a "separating strategy" - selling their product to all consumers on the home market at price p^p; and only to the rich consumers on the foreign market at price $\tau p^p < p^r$ - becomes a profitable option. In the following we show that, under high inequality, firms are strictly better off using this separating strategy than the "mass consumption strategy". The equilibrium is then characterized by the co-existence of exclusive firms and separating firms. (In constrast, when inequality is low, firms are strictly better off using this separating strategy than the "exclusive strategy". In that case, the equilibrium is characterized by the co-existence of mass consumption firms and separating firms.)

Let us first find the critical value of τ under which a separating strategy breaks even. A separating firm set $p^s = \tau p^p$ (the price she sets to rich consumers abroad). This yields profits

$$\Pi_S = (1-\beta)\,\tau p^p\mathcal{P} + p^p\mathcal{P} - \left(F + \frac{1+\tau\,(1-\beta)}{a}\mathcal{P}\right)$$

In the equilibrim with low trade costs, the zero-profit condition for exclusive firms $2p^p\mathcal{P} = F + (1+\tau)\,\mathcal{P}/a$ from which we can calculate p^p and insert the resulting expression in the above zero-profit condition for separating firms. This lets us calculate the critical value of τ such $\Pi_S \geq 0$ so that the separating strategy break even. This yields

$$\left((1-\beta)\,\tau^{ME}-1\right)\left(aF/\mathcal{P}+1+\tau^{ME}\right)+2\tau^{ME}\beta = 0.$$

For $\tau > \tau^{ME}$ where, we are in a high-trade-cost equilibrium where separating firms exist.

3.A.3.1 High inequality

With high inequality separating producers co-exist with exclusive producers. The zero-profit condition for a separating producer is

$$(1-\beta)\, p^r \mathcal{P} = F + \frac{1+\tau\,(1-\beta)}{a}\mathcal{P}$$

and for an exclusive producer we have

$$2\,(1-\beta)\, p^r \mathcal{P} = F + \frac{(1+\tau)\,(1-\beta)}{a}\mathcal{P}.$$

From these conditions we calculate the equilibrium prices

$$\begin{aligned} p^R &= \frac{1}{2\,(1-\beta)}\left(\frac{F}{\mathcal{P}} + \frac{(1+\tau)\,(1-\beta)}{a}\right) \\ p^p &= \frac{1}{2}\left[\frac{F}{\mathcal{P}} + \frac{1+\beta+\tau\,(1-\beta)}{a}\right]. \end{aligned}$$

Interestingly, inefficient trade occurs. Firms gain from exporting as long as $p^r > \tau/a$ which is equivalent to $1 + 1/(1-\beta)aF/P > \tau$.

Inserting the expression for prices into the budget constraint (the balance of payment condition holds through Walras' law) yields for rich agents

$$\frac{1-\beta\theta}{1-\beta}L = p^r\,(2N^r + N^p) + p^p N^p$$

and for poor agents

$$\theta L = p^p N^p.$$

The resulting equilibrium goods spectra are

$$N^p = \frac{2\theta a L}{aF/\mathcal{P} + 1 + \beta + \tau\,(1-\beta)}$$

and

$$N^r = \frac{(1-2\theta)\left(aF/\mathcal{P} + 1 + \beta + \tau(1-\beta)\right) + 2\theta\beta}{\left(aF/\mathcal{P} + 1 + \beta + \tau(1-\beta)\right)\left(aF/\mathcal{P} + (1+\tau)(1-\beta)\right)} aL.$$

We see that both N^p and N^r decrease in τ.

3.A.3.2 Low inequality

For lower levels of inequality at higher values of τ, an equilibrium situation emerges where the "exclusive" producers sell to all consumers at home but only to the rich abroad and the "mass" producers sell to all agents in both countries. By symmetry, we have factor price equalization and set $W = 1$.

$$\begin{aligned}
\Pi_M &: \; 2p^p\mathcal{P} = F + \frac{1+\tau}{a}\mathcal{P} \\
\Pi_S &: \; (1-\beta)\, p^r\mathcal{P} + p^p\mathcal{P} = F + \frac{1+\tau(1-\beta)}{a}\mathcal{P}.
\end{aligned}$$

The resource constraint and the budget constraints read

$$\begin{aligned}
L\mathcal{P} &= N^p\left[F + \frac{1+\tau}{a}\mathcal{P}\right] + N^r\left[F + \frac{1+\tau(1-\beta)}{a}\mathcal{P}\right] \\
\frac{1-\beta\theta}{1-\beta}L &= p^r N^r + p^p\left(2N^p + N^r\right) \\
\theta L &= p^p\left(2N^p + N^r\right).
\end{aligned}$$

Inserting the budget constraint of the poor in that of rich yields

$$\begin{aligned}
\frac{1-\theta}{1-\beta}L &= p^r N^r \\
\frac{\theta(1-\beta)}{1-\theta} &= \frac{p^p}{p^r}\left(2\frac{N^p}{N^r} + 1\right).
\end{aligned}$$

Prices are given by the zero profit conditions

$$\begin{aligned} p^p &= \frac{1}{2}\left[\frac{F}{\mathcal{P}}+\frac{1+\tau}{a}\right] \\ p^r &= \frac{1}{1-\beta}\left(\frac{1}{2}\left(\frac{F}{\mathcal{P}}+\frac{1+\tau}{a}\right)-\frac{\tau\beta}{a}\right) \end{aligned}$$

and we substitute this into the budget constraints of poor and rich households. This lets us solve N^p and N^r as ($p^p > \frac{\tau}{a}$ and $p^r < \tau p^p$)

$$\begin{aligned} N^r &= \frac{2(1-\theta)}{aF/\mathcal{P}+1+\tau-2\beta\tau}aL \\ N^p &= \frac{(2\theta-1)(aF/\mathcal{P}+1+\tau)-2\beta\theta\tau}{(aF/\mathcal{P}+1+\tau)(aF/\mathcal{P}+1+\tau-2\beta\tau)}aL. \end{aligned}$$

Note that a necessary condition for this equilibrium to emerge is $\theta > 1/2$. For $N^p > 0$, we must have $(2\theta-1)(aF/\mathcal{P}+1+\tau) > 2\beta\theta\tau$. Otherwise, the high-inequality equilibrium described above emerges. We also see that an increase in τ increases welfare of poor and rich households.

Chapter 4

Market entry costs and the cross-country variation in per capita incomes

4.1 Introduction

How important a determinant is international trade for the welfare of a country? And how much of the variation in incomes across countries can be attributed to differing degrees of integration into the global trade network? In this chapter I attempt at answering these question by adapting a quantitative version of the Melitz (2003) model as a development accounting framework. In its most stylized form development accounting assumes a Cobb-Douglas production function and compares the variation in incomes that are implied by the measured endowments (human and physical capital) to the actual variation in the data. This exercise typically finds that 40-50% of the variation can be explained with differing endowments. The remaining variation is attributed to exogenous differences in technology. Modern quantitative trade models as the one outlined in this chapter offer a structural interpretation for these technology differences.

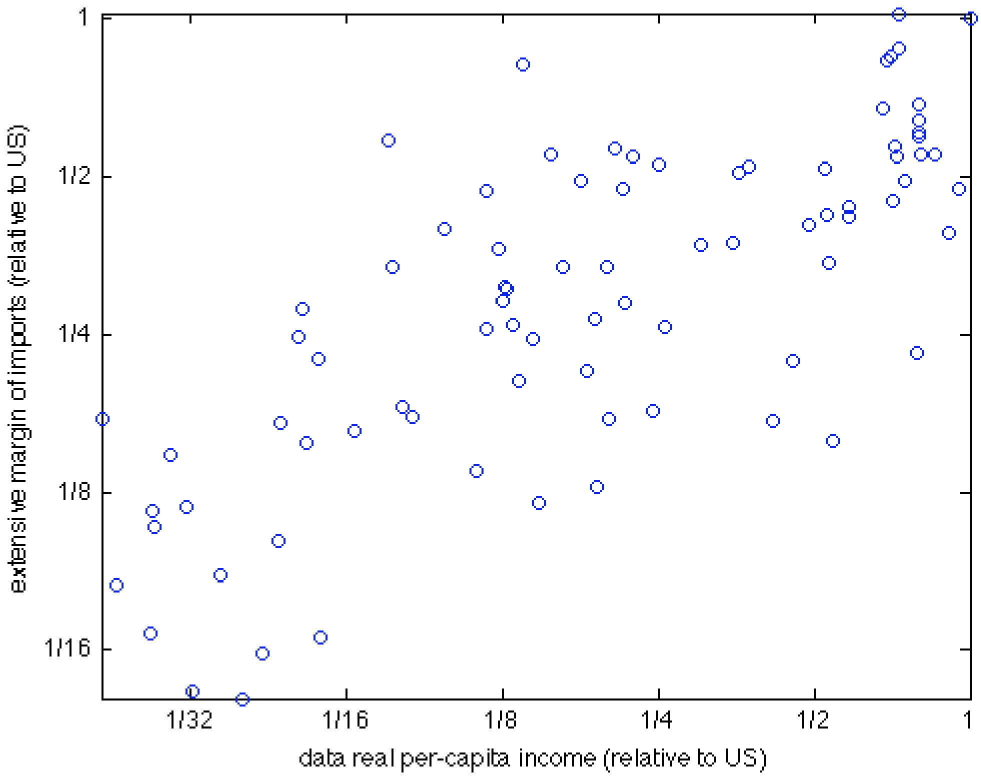
I see my framework as a parsimonious synthesis of the modern quantitative versions of the seminal Melitz (2003) model (see for example Eaton, Kortum, and Kramarz, 2008, Chaney, 2008, and Arkolakis, Costinot, and Rodríguez-Clare, 2010). It describes a multi-country world, where an endogenous set of heterogeneous firms produces tradable intermediates. These intermediates are bundled with local production factors to produce a non-tradable final good. Differences in the per capita consumption of the final good across countries are the model analogue to cross-country variation in real per capita incomes. In the model there are several channels for why per capita incomes may differ – unequal endowments and differing population sizes, exogenous technology variation, and trade-related mechanisms. Moreover these channels interact with each other. The trade-related mechanisms are driven by the presence of two types of trade frictions. Market entry costs require an exporter to invest a fixed amount of resources before he is able to sell his product in a new market and variable trade costs are proportional to the quantity that is shipped to a particular market. In order to develop an intuition for the role of these trade frictions it is helpful to think of an export- and an import-related effect. If the export destinations of a particular producer country have high entry costs or it is costly to ship to these countries demand for this exporting country's production factors is low, so that the incomes of the factor owners tend to be low too. If an importing country on the other hand has high entry costs or its location is relatively remote the measure of available intermediate varieties tends to be low and the prices of the varieties available tend to be high. Consequently, the local production cannot benefit too much from the existence of intermediates, which affect the output of the final good and thus real income. Moreover, since intermediates themselves are also inputs in the intermediate production this import channel spills back to the export channel.

In order to assess the actual relevance of these mechanisms I quantify the model economy by combining data on the aggregate values and the extensive margins of bilateral trade flows with the standard endowment data used in development accounting. I calibrate the model to match observed trade pattern. The thus quantified model does a remarkably good job in replicating the actual variations in incomes. To assess the quantitative relevance of trade frictions I perform two types of experiments. First, I consider a counterfactual world where countries are symmetric except for the calibrated trade frictions.

I find that there is almost no between-country inequality in such a world for both, fixed and variable trade costs. This finding however, is not sufficient to conclude that there is no role for trade-related elements in explaining cross-country variations in incomes, because trade frictions may only gain relevance when interacting with other asymmetries across countries. To investigate this possibility I perform a second type of counterfactual experiments, where I take the calibrated asymmetric countries and assess by how much between-country inequality is reduced when I consider a situation with symmetric trade frictions. I find that both giving all countries the same fixed entry costs or giving all country-pairs the same variable trade costs both reduce inequality by around 10%. In this sense the integration of a country in the global trade network seems to explain only a modest share of the observed variance in per capita incomes. Moreover, the effects are mostly driven by interactions with other asymmetries across countries.

This chapter is closely related to Waugh (2010), Finicelli, Pagano, and Sbracia (2009a), and Finicelli, Pagano, and Sbracia (2009b). These authors adapt the quantitative Ricardian trade model due to Eaton and Kortum (2002) and perform exercises that are similar in spirit to the ones outlined in this chapter. The advantage of the monopolistically competitive framework adapted here is the possibility of introducing fixed market entry costs. The potential relevance of entry costs can be seen from Figure 4.1 plotting the number of different imported intermediate varieties against real incomes. The clear positive relation is apparent and very much contradicts the Ricardian model, which actually predicts a strong negative relation (see previous chapter). Whereas I argue in the previous chapter that a similar positive relation for consumer goods is due to non-homothethic preferences, a natural candidate explanation for the case of intermediates is the presence of fixed market entry costs that negatively correlate with per capita income. The structural equations describing trade pattern in the Ricardian and in the monopolistically competitive framework look very similar and one may conclude that unless one is explicitly interested in fixed entry costs the choice of the modeling framework is not too relevant. In Section 4.3. I describe the commonalities and differences of the two frameworks and investigate if and how their quantitative predictions differ.

Figure 4.1: Number of different imported varieties vs. importer income



This chapter shows that trade frictions help to explain a part of the variation in incomes across countries. A complementary question considers a country's gains from trade and asks where these gains actually originate from? I investigate this question in an application of the model to Switzerland. I first rank the countries according to their contributions to Switzerland's gains from trade. Not surprisingly most gains originate from nearby European neighbors and large countries such at the USA and China. I then consider two counterfactual situations. In the first experiment I set the trade costs between Switzerland and particular foreign country to infinity and in the second experiment I consider a world where this foreign country does not exist at all. Both experiments yield surprisingly low compensating variations. This counterintuitively results highlight an important limitation of the approach taken in this chapter. I compare different equilibria of a static trade model (in a dynamic model this would correspond to comparing steady states) and use this as a development accounting tool. One has to be careful when directly drawing policy conclusions from the results, since the framework applied here cannot make statements about the transition path between static equilibria.

This chapter contributes to the very broad deleopment accounting literature surveyed for example in Caselli (2005) and Hsieh and Klenow (2010). An early paper discussing the effect of differing intermediate availability on incomes is Romer (1994). More recently Jones (2008) shows that allowing for an endogenous set of intermediates in an otherwise standard growth model explains a much larger share of the cross-country variation in incomes. Halpern, Koren, and Szeidl (2009) provide evidence that firms that use intermediates are more productive using. This chapter relates also to the gains from variety literature, implementing Feenstra's (1994) formula for the price index changes associated with new varieties. Important contributions include Broda and Weinstein (2006, 2006) and Hummels and Klenow (2005)s. My approach differs from this literature in specifying a fully structural model that allows me to quantify the relative importance of different elements of the model.

The chapter is organized as follows. The next section introduces the structural model. In Section 3 I present the data and outline the quantification strategy. Section 4 then presents the results of the quantification. In Section 5 I apply the model to Switzerland and Section 6 concludes.

4.2 The model

In the following I propose a simple and tractable quantitative model of the world economy. At its core are monopolistically competitive firms with heterogeneous productivities producing tradable intermediates. These intermediates are used as inputs in the intermediate industry itself and in a competitive final goods industry that produces a homogenous non-tradable consumption good.The model strongly draws on Eaton, Kortum, and Kramarz (2008), where elements that are used to match firm-level-facts (firm specific shocks to entry costs and market penetration costs à la Arkolakis, 2008) are muted for the sake of parsimony.

4.2.1 Structure of the economy

The world economy consists of N countries. Country i is inhabited by a measure $\mathcal{P}_i$ homogeneous agents, each endowed with h_i efficiency units of labor (human capital) and k_i units of capital. Labor and capital are internationally immobile, but perfectly mobile within countries.

4.2.1.1 The intermediate industry

The intermediate industry produces differentiated intermediate inputs that are internationally tradable. Setting up an intermediate firms requires capital k and labor l such that $k^{\alpha}l^{1-\alpha} \geq f_i^e$. After covering this initial setup cost the firm learns its productivity z and can produce a differentiated intermediate variety with the following CRS technology

$$y(z) = z\left(k(z)^{\alpha} l(z)^{1-\alpha}\right)^{\beta} q(z)^{1-\beta},$$

where $q(z)$ is a CES-aggregator over all available varieties Ω

$$q = \left(\int_{\Omega} x(j)^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\sigma}{\sigma-1}}.$$

The firm specific productivity is modeled as a realization of a Pareto random variable

$$\Pr\left[Z_i \leq z\right] = 1 - T_i z^{-\theta}.$$

T_i is a country specific parameter governing the lower bound of the productivity distribution (and thus also the expected productivity) and θ is a shape parameter common to all countries. There is free entry in the intermediate industry such that in equilibrium total operating profits just cover aggregate outlays for setup costs.

4.2.1.2 International trade

In order to enter a foreign market n producers from country i face two types of costs - fixed market entry costs and variable trade costs. Market entry requires local labor and capital inputs such that $f_n \alpha^\alpha (1-\alpha)^{(1-\alpha)} \leq k^\alpha l^{1-\alpha}$. For given factor prices an optimizing firm therefore needs to spend

$$E_n = f_n r_n^\alpha w_n^{1-\alpha}$$

in order to enter a market n. For future reference I will call f_n the market entry factor requirement of country n. Variable trade costs are of the Samuelsonian iceberg type, i.e. per d_{ni} units shipped in i only one unit arrives at the destination n.

4.2.1.3 Final goods industry

The final goods industry is competitive and produces a homogenous non-tradable consumption good. This good is the only quantity that yields utility for the agents. The final goods industry bundles capital, labor, and intermediates with a intermediate share of $(1-\gamma)$

$$y_F = \left(k_F^\alpha l_F^{1-\alpha}\right)^\gamma q_F^{1-\gamma}.$$

The final goods industry's intermediate aggregator has the same functional form as the intermediate industry's aggregator.[1]

4.2.1.4 Some equilibrium features

The Appendix provides a full derivation and description of the equilibrium of this model. Since the model is fairly standard I describe here only the main features and introduce some notation that will be needed later on.

In equilibrium each country i has a measure of $\mathcal{N}_i$ intermediate producers. The measure of entering firms is endogenous and adjusts such that the expected profit from entering is exactly zero. The variable production cost of a firm is given by the local unit costs[2]

$$c_i = \left(r_i^\alpha w_i^{1-\alpha}\right)^\beta P_i^{1-\beta}$$

[1] This can be generalized to different elasticities of substitutions, but does not deliver additional insights in the quantification.

[2] I omit here and in the following multiplicative constants that will be irrelevant for the quantitative behavior of the model.

scaled by the firm-specific productivity z, where P_i is the CES-price index. A firm compares the operating profits from entering a particular market n with the associated entry cost, E_n. I define the bilateral cutoff productivity z_{ni}^* as the productivity of the country i firm that just breaks even when entering market n. Firms in country i with productivities above z_{ni}^* will therefore find it optimal to export to n and firms with lower productivities will choose not to enter this market. Plugging the cut-off productivity into the country specific productivity distribution yields the share of i firms that enter n. The extensive margin of the trade flow from i to n follows from multiplying this share with the total measure of firms in i, $\mathcal{N}_i$. It can be shown to be

$$m_{ni} = \mathcal{N}_i T_i \left(c_i d_{ni}\right)^{-\theta} \left(c_n^*\right)^{\theta},$$

where c_n^* is the importing specific cut-off cost of delivering goods to market n above which firms find it optimal not to deliver the goods. For later use I denote the total measure of intermediate varieties that are available in country n by $M_n = \sum_{i=1}^N m_{ni}$.

Aggregating over all country i firms' revenues in market n yields the total value of the trade flow from i to n, X_{ni}. An importing country n demands intermediates as inputs into its own intermediate production and as inputs for the local final good production. Let X_n denote country n's intermediate absorbtion, i.e. the total value of its intermediate demand, $X_n = \sum_{i=1}^N X_{ni}$. I define the trade share λ_{ni} as the share of the importing country's intermediate demand that is met by the supplying country i

$$\lambda_{ni} = \frac{X_{ni}}{X_n}.$$

Balanced trade requires that a country i's total exports, $\sum_{n \neq i} X_{ni}$, equal that country's total imports, $\sum_{k \neq i} X_{ik}$. Adding the value of intermediate varieties that are bought from local producers, X_{nn}, allows me to write the balanced trade condition as

$$X_i = \sum_{n=1}^{N} \lambda_{ni} X_n.$$

To summarize, in this model international trade is in intermediates only. The trade patterns are characterized by the aggregate value of trade flows and their extensive margins and in equilibrium countries intermediate absorption equals the value of their intermediate production (balanced trade).

4.2.2 Real per capita incomes

Real per capita income in country n is given by the per capita consumption of the final good in this country, $U_n = y_{F,n}/\mathcal{P}_n$. I show in the Appendix that the equilibrium per capita income can be written as

$$U_n = A_n k_n^{\alpha\gamma} h_n^{1-\alpha\gamma}.$$

This expression for real per capita income looks very similar to the one of the standard development accounting framework (see e.g. Caselli (2005)) with the difference that A_n is not a mere residual, but has a structural interpretation

$$A_n = (w_n/P_n)^{1-\gamma}. \tag{4.2.1}$$

How does the fact that countries are integrated in a global trade network affect the wage rates and the intermediate price indices - and therewith real income - of a country? Let's consider first the price index, which can be written as (see Appendix)

$$P_n = \left(\frac{f_n}{\mathcal{P}_n (k_n)^{\alpha} (h_n)^{1-\alpha}}\right)^{\frac{1-\sigma+\theta}{\theta(\sigma-1)}} \left(\sum_{i=1}^{N} \mathcal{N}_i T_i (c_i d_{ni})^{-\theta}\right)^{-\frac{1}{\theta}}. \tag{4.2.2}$$

The term in the first bracket captures a variety effect.[3] The larger a market is (represented by the aggregate of human and physical capital) relative to market entry costs, the more firms will enter this market. More entrants in turn lower the price index via the love for

[3] I assumed that market entry costs are only destination market specific and affect local and international producers equally, which buys me a lot of tractability. If entry costs would be country-pair specific the variety effect would depend on an aggregate of supplier specific entry costs. Since it is not clear how one would implement such a more general model empirically, I abstained from modeling such country-pair specific entry costs and chose the more parsimonious formulation of destination specific entry costs.

variety built into the CES production function. The second bracket captures the effect of international trade on prices. The countries' technologies, T_i, are weighted by the local unit costs, the bilateral distance, and the measure of firms. If a country is favorably positioned in the global trade network (a favorable position could be low trade costs in general or proximity to technologically advanced countries or countries with many firms) the average price of the varieties supplied in its market will be low and correspondingly it will have a low intermediate price index.

The wage rate on the other hand is determined by the global demand for county i labor. To elaborate on this I use the fact (shown in the Appendix) that a country's total intermediate absorption, X_n, is proportional to total labor income in this country, $w_n h_n \mathcal{P}_n$. Substituting this into the balance of payments yields

$$w_i h_i \mathcal{P}_i = \sum_{n=1}^{N} \lambda_{ni} h_n \mathcal{P}_n w_n. \tag{4.2.3}$$

This equation can be read as a labor market clearing condition with the wage rate adjusting such that global demand for country i's labor (the left hand side) equals total supply of labor in country i. Global demand for country i labor is driven by the market sizes of the trading partners, $h_n P_n w_n$, and the bilateral trade shares λ_{ni}. In the Appendix I show that the trade shares are proportional to the extensive margin relative to totally available varieties in the importing country, $\lambda_{ni} = m_{ni}/M_n$. Substituting for the extensive margins I can write

$$\lambda_{ni} = \frac{\mathcal{N}_i T_i \left(c_i d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} \mathcal{N}_k T_k \left(c_k d_{nk}\right)^{-\theta}}. \tag{4.2.4}$$

Thus, a country i tends to have a high wage rate if it has a good technology, if it has a large number of firms, if the trade costs with its trading partners are low or if unit costs are low (for example due to a low intermediate price index). A country also has a high equilibrium wage rate if it is close to large markets so that for given trade shares the demand for its factors is high.

In summary, international trade affects a country's per capita income trough imports via a lower price index and through exports via high demand for a country's factors due to international trade.

4.3 Quantification

Having developed a parsimonious model of the global economy I seek to quantify this model. This will allow me to compare the model's predicted per capita income with the data and later on to consider the relative importance of the building blocks for explaining the cross country variation in incomes.

4.3.1 Data

In order to quantify the model I use data on aggregate values of bilateral trade flows, the extensive margin of bilateral trade flows, endowments, population sizes, and proxies for trade costs. I calibrate the model to the year 2003. The number of countries in the sample is determined the set of countries for which all data is complete. In the following I briefly describe the data. Table 4.1 summarizes the availability of the different data and describes the resulting data set.

4.3.1.1 Aggregate values and extensive margins of bilateral trade

In order to compute the aggregate values and extensive margins of bilateral trade I use the COMTRADE database as provided by the Centre d'Edutes Prospectives et d'Informations Internationales (Gaulier, Zignago, Sondjo, Sissoko, and Paillacar, 2010). For the year 2003 this dataset provides the dollar values of bilateral trade flows aggregated at the HS6 level for over 200 economic entities (mostly countries). I consider only HS-categories that are classified as manufactures in Gaulier, Zignago, Sondjo, Sissoko, and Paillacar (2010) since the model is one of trade in manufactures.[4] Summing over all manufacturing HS-categories I get the aggregate value of the bilateral trade flow from i to n, X_{ni}. Counting

[4]Additionally I experimented with considering only intermediate manufactures. The results do not change. I use total manufactures since the data for gross output are not classified as intermediates or consumer goods. In my experiments I used the intermediate share of a countries export to infer this country's gross output in intermediate manufactures.

the number of manufacturing HS-categories with positive values gives me a measure for the extensive margin of the bilateral trade flow from i to n, m_{ni}. Clearly, it is very likely that the trade flow within a HS-category is an aggregate over several firms, so that my count measure is only a proxy for the true extensive margin.[5]

4.3.1.2 Endowments and population sizes

Human capital h_i is taken from Caselli (2005) who uses the data of Barro and Lee (2001). These authors compute human capital as a piece-wise log-linear function of average years of schooling of a country's population over 25 year. The capital stocks are constructed using the perpetual inventory method outline in Caselli (2005) using data on aggregate investment from Heston, Summers, and Aten (2009).[6] Population sizes are taken from the Worldbank's World Development Indicators (World Bank, 2010)

4.3.1.3 Gross output

GDP measures the total value added in an economy. To quantify this model however, I will need a measure the total value of a countries intermediate output (including the value of inputs), $\sum_{n=1}^{N} X_{ni}$. UNIDO (2003) provides estimates for gross manufacturing output for 77 countries. Additionally they provide estimates for the value added in agriculture and manufacturing for 192 economic entities. In order to impute gross manufacturing output for the countries with value added data, but no gross output data, I follow Simonovska and Waugh (2010) and run a 3rd order polynomial regression of gross manufacturing output on the value added shares, GDP, and population size.

[5] Even firm level data usually only proxies the true extensive margin since many firms export several products.

[6] I take the year 1978 as the initial year. The initial capital stock is computed as $I_{1978}/(g+\delta)$, where I_{1978} a country's aggregate investment in 1978, g is this country's average growth rate in aggregate investment between 1970 and 1978, and $\delta = 0.06$ following Caselli (2005). Based on this initial capital stocks I then construct the capital stock for the year 2003 by iterating the capital accumulation function, $K_{t+1} = (1-\delta) K_t + I_t$.

Table 4.1: Data availability and the resulting data set

data availability	
data	observations
trade pattern (X_{ni}, m_{ni})	221
endowments (h_i, k_i)	104
population sizes	227
gross output - measured	77
gross output - imputed	118
trade cost proxies	224
resulting data set	
number of countries	86
% of global gdp	87%
% of global trade volume	64%

4.3.1.4 Trade cost proxies

Since I do not directly observe the variable bilateral trade costs, d_{ni}, I will estimate these trade costs. For that I will follow the Gravity literature in using the usual proxies - bilateral distance, a shared border, and speaking the same languages. The corresponding data is from CEPII (2006).

4.3.2 Transforming the data into inputs for the quantification

The available data described above requires some manipulation to be useful as an input for the quantification. These transformations are guided by the theoretical model and are described in the following.

4.3.2.1 Total manufacturing absorption and trade shares

We have data on a country i's total manufacturing output, $\sum_{n=1}^{N} X_{ni}$. Subtracting the aggregate value of this country's exports, $\sum_{n \neq i} X_{ni}$, yields i's manufacturing demand that is met by local producers, X_{ii}. Adding all imports from countries that are in the sample[7]

[7] Note that I subtracted total exports (to countries that are in the sample and countries that are not) since this yields as the residual X_{ii}. However, I add only imports from countries in the sample in order

gives me the gross value of this country's total intermediate demand, X_i. The bilateral trade shares, λ_{ni}, follow immediately by dividing the aggregate value of the bilateral trade flow from i to n by the importing country total manufacturing absorption, $\lambda_{ni} = X_{ni}/X_n$. The home share, λ_{nn}, is computed as a residual, $\lambda_{nn} = 1 - \sum_{i \neq n} \lambda_{ni}$.

4.3.2.2 Wage rates

Since I am interested in between-country inequality I want to have a sample of countries that is as large as possible. Using actual wage data would restrict me to considering basically only OECD countries. To avoid this I follow Waugh (2010) and take the wage rates that are implied by the general equilibrium. Slightly rearranging (4.2.3) I get

$$w_i = \sum_{n=1}^{N} \lambda_{ni} \frac{h_n \mathcal{P}_n}{h_i \mathcal{P}_i} w_n.$$

Using the data on population sizes and human capital and the trade shares derived above this represents a linear system that can be solved for the unique set of relative wage rates consistent with market clearing.

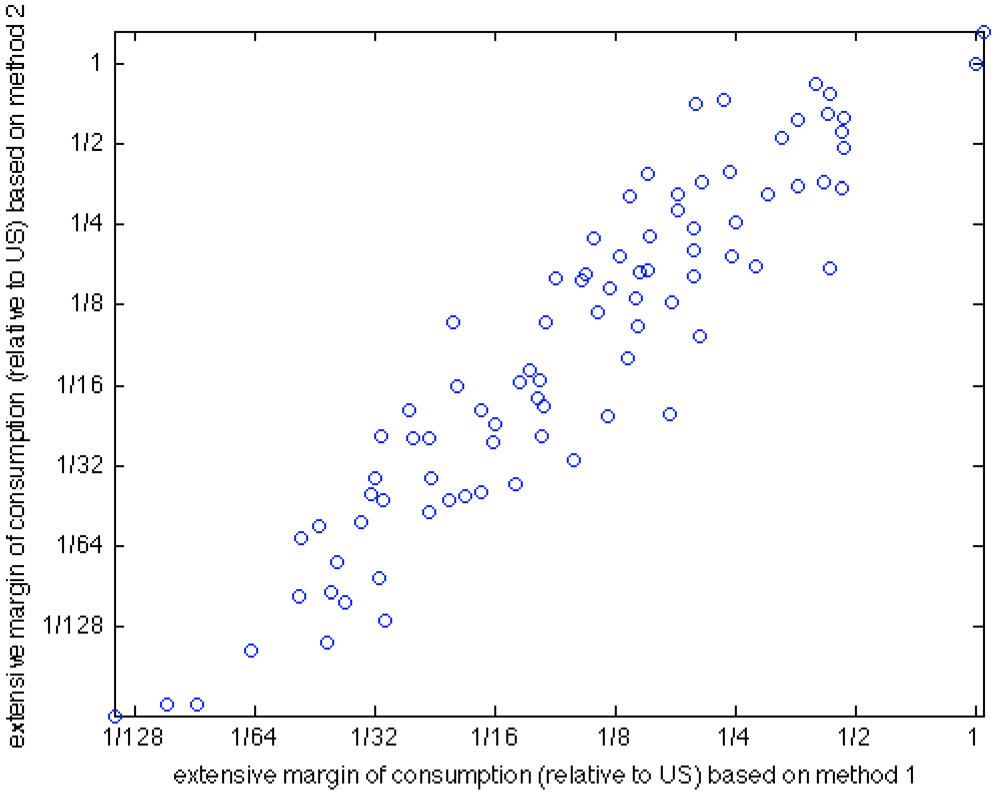
4.3.2.3 Total measure of locally available varieties, M_n

In the data we observe the measure of imported manufacturing varieties, $\sum_{i \neq n} m_{ni}$, but not the measure of locally sourced varieties, m_{nn}, so that we cannot directly compute $M_n = \sum_{i=1}^{N} m_{ni}$. In the following I discuss two methods for imputing the total measure of available varieties, M_n.

For the first approach remember that the trade share of an exporting country i in the market n equals the share of varieties that this exporter supplies in market n, $\lambda_{ni} = m_{ni}/M_n$. Adding over all exporters and rearranging yields $M_n = (1 - \lambda_{nn}) \sum_{i \neq n} m_{ni}$. From above we know the extensive margins of imports, m_{ni}, and the home share λ_{nn} so that we can directly solve for the implied measure of totally available varieties. An alternative approach combines and rearranges two expressions for the trade share, $\lambda_{ni} = X_{ni}/X_n$ and $\lambda_{ni} = m_{ni}/M_n$, to show that the average intensive margin of a country's

to obtain a measure for intermediate absorption consistent with the model.

Figure 4.2: Comparing the two approaches to estimating M_n



import flows in proportional to this country's entry costs

$$\frac{X_n}{M_n} = \frac{X_{ni}}{m_{ni}} = \frac{\sigma\theta}{\theta - \sigma + 1} E_n.$$

Adapting a stochastic version with a multiplicative error for this equation I obtain an estimate for $\log(E_n)$ (up to a constant) by regressing $\log(X_{ni}/m_{ni})$ on country fixed effects.[8] I obtain an estimate for M_n by dividing the total intermediate absorption, X_n, by the previously estimated E_n.

Figure 4.2 plots the resulting estimates for M_n against each other. Clearly the resulting estimates are highly correlated. I use the M_n computed with the first approach in what follows. The results remain unchanged when using the alternative estimates for M_n.

[8]This is of course equal to taking the geometric mean across supplier countries.

4.3.3 Quantifying the model

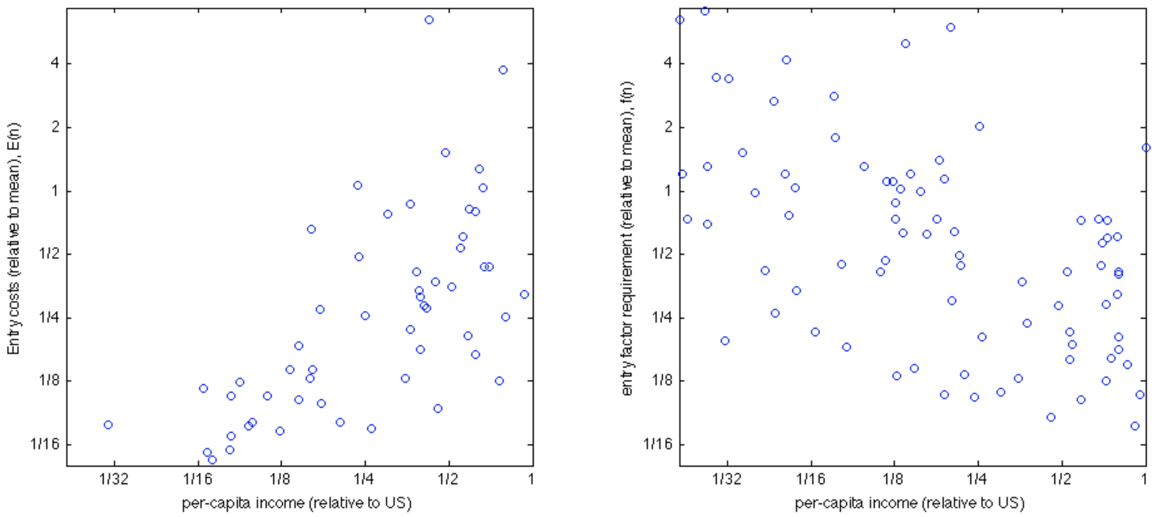
The model parameters are the countries endowments, k_i and h_i, the population sizes, $\mathcal{P}_i$, the technologies, T_i, the setup costs parameters, f_i^e, the market entry cost parameters, f_i, the matrix of bilateral trade costs, d_{ni}, and a set of parameters common to all countries, α, β, γ, θ, and σ. Some of the parameters directly correspond to data (k_i, h_i, and $\mathcal{P}_i$). Others will be estimated using the preparatory work done in the previous section (T_i, f_i^e, f_i, and d_{ni}) and for the remaining parameters I will use standard values commonly used in the literature. In the following I first describe these standard values and then discuss the estimation strategies for T_i, f_i^e, f_i, and d_{ni}.

4.3.3.1 Labor share, intermediate shares, and trade elasticity

The Pareto shape parameter θ governs the elasticity of trade with respect to trade costs. I use the estimate from Eaton, Kortum, and Kramarz (2008) of $\theta = 4.87$, which follows from fitting their model to French firm-level data. [9] For the intermediate share in the tradable manufacturing sector I follow Waugh (2010) in choosing $\beta = 1/3$, which is the average value added in UNIDO manufacturing data for 61 countries. I follow Alvarez and Lucas (2007) in choosing $\gamma = 3/4$ and for α I choose $\alpha = 1/3$ to get the common assumption of a labor share of 2/3. For the elasticity of substitution finally note that in contrast to the Ricardian frameworks used e.g. in Alvarez and Lucas (2007) and Waugh (2010) the value of the elasticity of substitution matters very much for the quantitative behavior of the model. The reason is that the elasticity of substitution governs the demand elasticity and thus the markups. The markups in turn determine how many firms find it profitable to enter a market and therefore the set of available varieties. As a baseline I choose a $\sigma = 3.4$, which is the median value of the elasticities estimated in Broda, Greenfield, and Weinstein (2006). I discuss the sensitivity of the results with respect to the chosen parameter values in Section 4.6.

[9] More recently Simonovska and Waugh (2010) estimate the trade elasticity for a broad set of countries and provide strong evidence that there is no systematic correlation between the trade elasticity and the level of a country's development - their baseline estimate is $\theta = 4.5$. In Eaton and Kortum (2002) the authors propose three approaches to estimating θ. The resulting values are 3.6, 8.28, and 12.68.

Figure 4.3: Market entry costs, E_n, and factor requirements, f_n



4.3.3.2 Fixed market entry costs

In order to get an estimate for the fixed market entry costs I rearrange (4.A.1) to use $E_n = X_n/M_n$ (ignoring multiplicative constants, see Appendix for derivation). Since I have values for the intermediate absorption and the total measure of available varieties I can calculate the implied market entry costs. The upper panel of Figure 4.3 plots those against real per capita incomes (as measured in the Penn World Tables, Heston, Summers, and Aten, 2009). There is clearly a positive relation between per capita income and market entry costs. However, there are two possible reasons for why E_n is high - high market entry factor requirements, f_n, or high local factor prices. Whereas the first reason is indeed unambiguously bad for a country, the second reflects this country's strength. Indeed the lower a factor requirement for entry the higher this country's factor productivity and consequently its factor prices. In order to isolate the effects I substitute for E_n and solve for the factor requirement

$$f_n = \frac{1}{w_n}\left(\frac{h_n}{k_n}\right)^{-\alpha}\frac{X_n}{M_n}.$$

Since I have data on the relative capital stocks and I computed the wage rates above I can implement this equation and construct the implied factor requirements. The lower panel of Figure 4.3 plots these factor requirements against real per capita incomes revealing that the factor requirements itself are clearly negatively correlated with per capita incomes. In the counterfactual experiments I will assess how important the fact that poor countries have high factor requirements is for the pattern of between-country inequality.

4.3.3.3 Variable trade costs

I obtain an empirically implementable gravity equation by normalizing the trade shares with the importing country's home share

$$\frac{\lambda_{ni}}{\lambda_{nn}} = (d_{ni})^{-\theta} \frac{S_i}{S_n},$$

where $S_i = \mathcal{N}_i T_i c_i^{-\theta}$. Since I cannot directly observe the trade costs I model them as a function of observables and an exporter fixed effect

$$-\theta \log (d_{ni}) = d_k + b + l + ex_i + \delta_{ni},$$

where I suppressed the dummy variables for notationally simplicity. d_k is the effect of the bilateral distance being in the interval k. Similar to Eaton and Kortum (2002) the intervals are (measured in miles) $[0, 375)$, $[375, 750)$, $[750, 1500)$, $[1500, 3000)$, $[3000, 6000)$, and $[6000, \infty)$. b is the effect of sharing a bilateral border and l the effect of having a common language. ex_i is an exporter fixed effect. Whereas the explanatory power of this regression would be the same using importer fixed effects instead, Waugh (2010) demonstrates that exporter fixed effects yield consistent results along other dimensions, in particular with respect to the price-indices of tradable goods across countries. Inserting the functional assumption about trade costs into the normalized trade share equation and taking logs yields a linear equation that is straight forward to implement.

Table 4.2 reports the estimated coefficients and the implied percentage effect on trade costs for the OLS regression and the Poisson pseudo maximum likelihood (PPML) regression proposed by Silva and Tenreyro (2006). In our context, the main advantage of the PPML approach is its ability to use also zero trade flows. This may be relevant in the present sample since 13% of all possible trade flows are zeros. The correlation between

Table 4.2: Trade cost coefficients and implied effects

	Poisson regression		OLS regression	
variable	coefficient	%-effect	coefficient	%-effect
$[375, 750)$	-0.32^{**}	7%	-0.59^{**}	13%
$[750, 1500)$	-0.65^{***}	14%	-1.15^{***}	27%
$[1500, 3000)$	-1.98^{***}	50%	-2.32^{***}	61%
$[3000, 6000)$	-2.86^{***}	80%	-3.51^{***}	106%
$[6000, \infty)$	-3.32^{***}	98%	-4.33^{***}	143%
shared border	0.50^{***}	-10%	1.01^{***}	-19%
same language	0.50^{***}	-10%	0.92^{***}	-17%

the trade costs implied by OLS and PPML however is high with 0.85. With the estimates based on PPML being less spread out. In order to preserve comparability with Waugh (2010) I choose to use the trade costs estimated with OLS.

4.3.3.4 Technologies

I recover technologies by using the general equilibrium conditions of my model. Market clearing requires (4.2.3) to hold for every country. Substituting for the countries' unit costs I can write the trade shares as

$$\lambda_{ni} = \frac{\widetilde{T}_i \left(w_i^\beta P_i^{1-\beta} d_{ni} \right)^{-\theta}}{\sum_{k=1}^N \widetilde{T}_k \left(w_k^\beta P_k^{1-\beta} d_{nk} \right)^{-\theta}},$$

where $\widetilde{T}_i = (h_i/k_i)^{-\alpha\beta\theta} \mathcal{N}_i T_i$ is a composite of a country's technology, its measure of entrants, and the ratio of human and physical capital. Adapting this composite expression the price yields

$$P_n = (M_n)^{\frac{1}{\theta}+\frac{1}{1-\sigma}} \left(\sum_{i=1}^N \widetilde{T}_i \left(w_i^\beta P_i^{1-\beta} d_{ni} \right)^{-\theta} \right)^{-\frac{1}{\theta}}.$$

From above I have values for M_n, w_n, h_n, $\mathcal{P}_n$, d_{ni} for the parameters β, σ, and θ. Given these I can solve for the (up to a constant) unique vector of $\widetilde{T}_i$ for which the corresponding price indices and trade shares ensure that all markets clear.[10] Solving for the corresponding technologies T_i is then straight forward. In the appendix I discuss an alternative approach to calibrating the technologies and show that the resulting technologies are highly correlated with the ones recovered above.

4.4 Results

In the previous section I described how I calibrate the model and briefly discussed the resulting values. In this section I now turn to the actual question of this chapter - how does considering the global macroeconomy help us to understand variations in income that may be interpreted as pure technological variations using a closed economy framework? To answer this question I first compare the global variation in per capita incomes generated by the model with the data. Later I then consider the relative importance of different aspects of the model in explaining global income inequality.

4.4.1 Comparing global inequality in the model and the data

To calibrate the model I combined standard endowment data with data on trade flows, but I did not use data on per capita incomes. How do the per capita incomes generated by the model line up with the data? Figure 4.4 plots the model's incomes against the data. The model captures the variation in the data quite well. Indeed the slope of the best fit through Figure 4.4 is 1. To assess the model's performance one can also compare the variance in incomes and percentile ratios of the model and the data in the spirit of Caselli (2005). Table 3 reports the respective values. The model's variance in log-incomes and the 90/10-percentile ratio are slightly too high, whereas the 75/25-percentile ratio is lower than in the data.

In the data there is a strong correlation between the reduced form TFP and the capital-labor composite, $k^{\alpha}l^{1-\alpha}$, with a correlation coefficient of 0.87. The correlation

[10]In the code I start with an initial guess for $\widetilde{T}_i$. Based on this guess I first compute the implied price indices. Using these I then calculated the corresponding trade shares. I plug the trade shares into the market clearing conditions and check by how much the markets fail to clear. I adjust the initial guess using a tâtonnement-like algorithm until all markets clear.

Figure 4.4: per capita incomes of the model and in the data

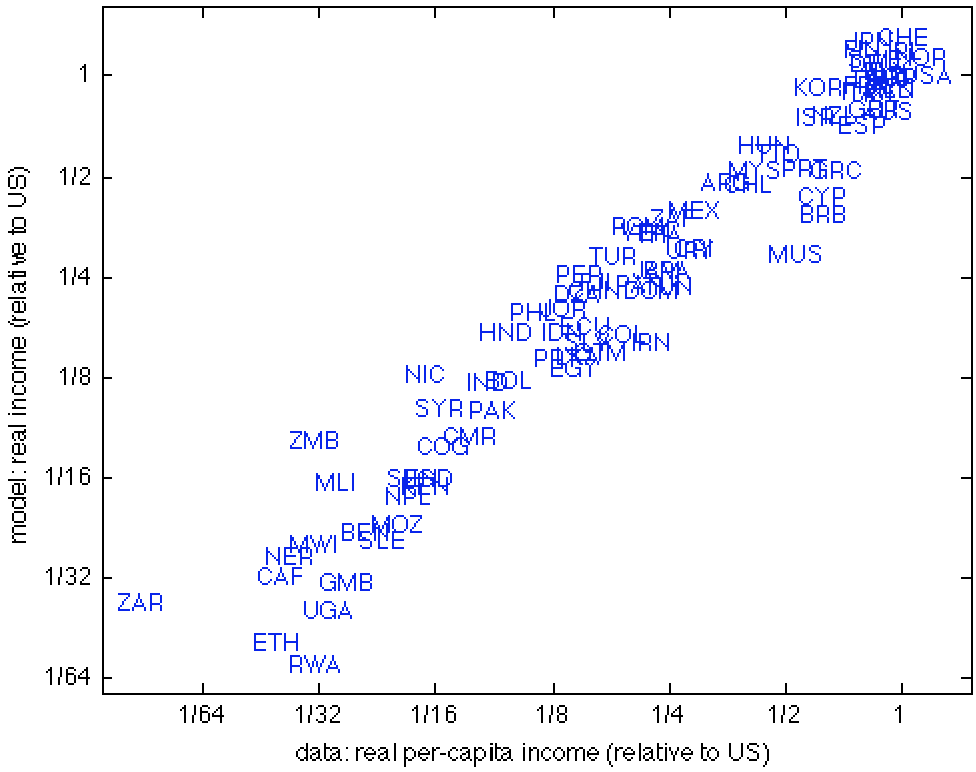


Table 4.3: Income differences in the model and the data

	var (log (U))	$p_{90\%}/p_{10\%}$	$p_{75\%}/p_{25\%}$
data	1.44	25.8	7.7
model	1.53	29.8	6.7

of the model's reduced-form TFP with the capital-labor composite is very similar with 0.91. To summarize, the model seems to replicate the actual between-country inequality remarkably well. I now turn to investigate which elements of the model actually drive inequality.

4.4.2 The Sources of inequality

To discuss the sources of between-country inequality it is helpful to go back to (4.2.1). After some manipulations outlined in the Appendix I obtain the following expression for real income in country n

$$U_n = (\lambda_{nn})^{-\frac{1-\gamma}{\beta\theta}} (f_n)^{-\frac{1-\sigma+\theta}{(\sigma-1)\beta\theta}(1-\gamma)} \mathcal{P}_n^{\frac{1-\gamma}{\beta(\sigma-1)}} \left((k_n)^{\alpha} (h_n)^{1-\alpha}\right)^{\frac{1-\gamma}{\beta(\sigma-1)}} \left(\frac{T_n}{f_n^e}\right)^{\frac{1-\gamma}{\beta\theta}} k_n^{\alpha} h_n^{1-\alpha}. \quad (4.4.1)$$

This expression nicely highlights the different elements of the model and how they affect a country's per capita income. The capital-labor composite, $k_n^{\alpha} h_n^{1-\alpha}$, is the standard explanatory variable of the simple development accounting framework. The next term, T_n/f_n^e, represents exogenous variations in technologies (relative to set-up costs for firms). The third term is a multiplier on the capital-labor composite coming from the two stage production with love from variety. The fourth term is a scale effect - larger countries have higher demand and therefore it is more attractive to enter these markets, which lowers the price index. Similarly, the market entry factor requirement, f_n, affects the measure of entering firms - the lower it is the more firms enter a market for a given size. The last element is the home share, λ_{nn}, that captures the effect of international trade. With a home share of 1 a standard lives in autarky. The lower the home share the higher the benefits from trade and the higher real income U. Note that all previous elements also affect the equilibrium value of the home share. In the following I will consider the quantitative importance of these elements separately.

4.4.2.1 Endowment Differences, country sizes, and technologies

In the the baseline development accounting framework endowment differences explain about 37% of the variance in per capita incomes. In the present model endowment differences have additional effects via the love for variety production functions and the home share. I first focus on the production function channel. Setting trade costs to infinity (and thus the home shares to 1) and giving all countries' the same technologies, factor requirements, f_n and f_n^e and populations, I can assess the additional explanatory power coming from having a two stage production process. The resulting variance in the logs of per capita incomes is 0.63% relative to the data, which is significantly higher than the usual 40%. This result is reminiscent of Mankiw, Romer, and Weil (1992) who find that increasing the weight on capital in the production process helps replicating the

Table 4.4: The role of trade-related elements in an otherwise symmetric world

countries are symmetric except for...	var (log (U))
... market entry costs, f_n	0.01
... trade costs, d_{ni}	0.05
... market entry and trade costs	0.06
data	1.44

observed differences in per capita incomes. When I additionally allow for the scale effect by plugging in the actually observed populations I obtain a log-variance in incomes of 73% relative to the data. Considering technology first note that one cannot separately identify the factor requirement for setting up a firm f_n^e and a country's technology. Thus I lump the two together and call the resulting ratio technology. When we additionally allow for technological differences the explained variance rises to 77%.

4.4.2.2 Fixed and variable trade costs

How important is the imperfect global integration for the patterns of inequality between countries? In order to assess this question I make the countries symmetric along all dimensions except for the market entry factor requirement, f_n, and the trade costs. In this way I preclude interactions between endowments and technologies and trade related elements of the model. Table 4.4 summarizes the results. Clearly, taken for themselves trade barriers seem not to be important in generating between-country inequality. If one considers a world with symmetric countries except for the calibrated asymmetries in fixed and variable trade costs the corresponding log-variance in per capita incomes would only be 0.06 which is very small relative to the 1.44 in the data.

However, the real world is not symmetric and a question of more policy relevance is therefore how inequality reacts to changes in trade costs given asymmetries in endowments, populations, and technologies. The results may differ due to interactions of the trade-related elements with other asymmetries in the model. Table 4.5 reports the percentage changes in the variance of log-incomes that are associated with changes in fixed

Table 4.5: Reductions in inequality associated with changes in trade costs

counterfactual experiment	% change in var $(\log(U))$
$f_n = \min\{f_k\}_{k=1}^{N}$	-12.8%
$d_{ni} = \text{mean}\{d_{ni}\}_{i \neq n}$	-12.5%
above experiments combined	-22.7%

and variable trade costs. Given the actual asymmetries in endowments, populations, and technologies introducing symmetry in trade costs has about the same effect for variable and fixed trade costs. The resulting reductions in inequality are non-neglible, but rather small when compared to the reductions that are for example associated with giving all countries the same endowments of human capital (-31%) or physical capital (-76%). In summary, I therefore conclude that there is some relevance of asymmetries in trade costs for understanding the observed between-country inequality. The effects come mostly from interactions with other asymmetries (endowments and population sizes). In spite of the relatively small effects the results may be of interest for policy-makers since asymmetries in trade costs can be influenced immediately to the extent that they are due to regulatory asymmetries, whereas policy changes aiming at influencing asymmetries in human or physical capital require time for the capital stocks to adjust.

4.4.3 How do the results compare to a Ricardian setup?

The model proposed above features monopolistically competitive firms, market entry costs, and an endogenous set of firms. The Ricardian model proposed by Waugh (2010) based on Eaton and Kortum (2002) features perfect competition, no market entry cost, and an exogenous set of varieties. The resulting structural equations (I outline the corresponding model in the Appendix), however, look very similar to the ones resulting from my model. Indeed, the Ricardian model in the spirit of Waugh (2010) and monopolistic competition models as outlined in this chapter are emerging as the two most prominent quantitative trade models. Which of the two frameworks is chosen for a given question is usually a question of parsimony - if the research question is more concerned with aggregate trade pattern the simpler Ricardian model is often chosen, whereas endeavors investigating firm level facts tend to use the monopolistic competition framework. Arkolakis, Costinot, and Rodríguez-Clare (2010) show that both models belong to a more general class of model for which the gains from trade (the compensating variation when comparing a trade equilibrium with autarky) are fully summarized by a country's home share and the trade elasticity.[11] However, this does not imply that the predicted changes in welfare as a reaction to common elements (e.g. variable trade costs or endowments) are the same since the home share may adjust differently. In this section I investigate how different the two classes of models' quantitative predictions are.

In terms of the quantification, the two main differences between the Ricardian and the monopolistically competitive setup are the interpretation of the reduced form technology, $\widetilde{T}_i$, and the fact that in the monopolistic competition case the countries price indices scale by the measure of locally available varieties. In the quantification, this implies that the explanatory power of the endowments is higher in the monopolistically competitive environment, whereas these additional channels are lumped into technology in the Ricardian framework. As long as one does not consider counterfactual experiments with respect to endowments this difference does not directly matter. However, interactions between the scale effects and trade costs may imply that even experiments that leave endowments constant yield quite different predictions depending on which framework is used. In order to assess if this concern is of quantitative importance I calibrated the two model to the data used above and performed three experiments with respect to trade cost. The first experiment gives all country-pairs the same average trade costs, the second experiments is Waugh's (2010) experiment of making trade costs symmetric[12], and the third experiment gives all country-pairs the average trade costs among OECD countries. Table 4.6 summarizes the results. Concerning the models' abilities to replicate the actual variance in incomes both models slightly overpredict with the Ricardian doing so more strongly.

[11] To be precise, in the context of my model, the trade elasticity is not sufficient, but we actually need the combination of trade elasticity and labor shares, $-(1-\gamma)/(\beta\theta)$.

[12] Remember that we included exporter fixed effects in the gravity equation. This implies that if e.g. Switzerland has a lower exporter fixed effect than the US, the trade costs for shipping from US to Switzerland are higher than the costs for flows in the other direction. In this experiment I abolish this asymmetry, $d_{ni}^{new} = \min(d_{ni}, d_{in})$.

Table 4.6: Comparing the monopolistically competitive and the Ricardian setup

comparison of ability to reproduce the data

	$\text{var}(\log(U))$
data	1.44
monopolistic competition model	1.53
Ricardian model	1.64

comparison of predicted % reduction in $\text{var}(\log(U))$

	predictions	
experiment	monop. comp.	Ricardian
$d_{ni} = \text{mean}(d_{ni})$	-13%	-1%
$d_{ni} = \min(d_{ni}, d_{in})$	-20%	-19%
$d_{ni} = \text{mean}\left(d_{ni}^{OECD}\right)$	-26%	-24%

In the counterfactual experiments the models yield similar for the last two experiments and very different predictions in the first experiment. Therefore I conclude that there are indeed situations where the two classes of models yield very different predictions and correspondingly quantitative work in international trade should check if the results strongly depend on the chosen model. If they do, the justification for the choice of the framework has to go beyond the argument of parsimony.

4.5 Application: the Swiss gains from trade

Based on (4.4.1) we can compute the gains from trade for each country by raising the calibrated home share, λ_{nn}, to the power of $-(1-\gamma)/(\beta\theta)$. In this section I investigate the gains from trade for Switzerland. The calibrated home share for Switzerland is 0.09, so that the implied welfare gain (measured as the compensating variation) is 46%.

Where do these gains originate from? A simple first approximation is to note that the home share is defined as $\lambda_{nn} = 1 - \sum_{i \neq n} \lambda_{ni}$. Thus, simply ordering the supplier countries by their bilateral shares yields a ranking of the importance of these countries for the importer's welfare. Column 2 of Table 4.7 provides the respective ranking for

Switzerland's 15 most important trading partners.

Table 4.7: Decomposing Switzerland's gains from trade - top 15

	Ranking		Change in welfare	
Trading partner	model-based	data-based	Experiment I	Experiment II
Germany	1	1	-6.4%	-5.0%
Italy	2	2	-3.9%	-3.3%
France	3	3	-3.4%	-2.4%
UK	4	7	-0.4%	0.1%
Belgium + Lux	5	9	-1.7%	-1.0%
Austria	6	5	-0.6%	-0.4%
Spain	7	11	-0.3%	0.0%
USA	8	4	-1.4%	0.6%
Holland	9	6	-0.5%	-0.1%
China	10	10	-0.0%	0.3%
Sweden	11	13	-0.1%	0.0%
Japan	12	12	-0.1%	0.7%
Denmark	13	15	-0.1%	0.0%
Irland	14	8	-0.2%	0.0%
Finland	15	19	-0.1%	0.0%

The set of the top15 trading partners for Switzerland in the model overlaps with the corresponding set in the data for all but one country (Finland is the 15th most important trading partner in the model, whereas the corresponding country in the data is Thailand). Column 3 presents the ranking based on the actual data. In order to quantify the gains I perform two counterfactual experiments. In the first experiment I set the bilateral trade costs between Switzerland and a particular trading partner i, $d_{CH,i}$, to infinity and compare the associated compensating variation to the overall gains from trade. Note that whereas in this experiments direct trade between Switzerland and country i does not emerge[13], indirectly Switzerland still benefits from the presence of country i, because country i supplies other countries with intermediate varieties and therewith lowers their unit costs, which indirectly also affects the price level in Switzerland. Column 4 of Table

[13]Trade in which a third country merely acts as a transit point is ruled out by assumption.

4.7 reports the corresponding welfare contributions. The second experiment fully removes a county from the global trading system, i.e. I set the trade costs between a country i and all other countries to infinity. Column 5 of Table 4.7 reports the associated welfare changes. In contrast to the first experiment, where all welfare changes are negative, there are 45 countries whose disappearance from the global trade system would actually benefit Switzerland. The reason for this surprising result is that the disappearance of these countries increases the demand for Swiss factors. This raises the wage rate in Switzerland. At the same time the disappearance of a country implies that the intermediate price index is rising since this country's varieties disappear. From (4.2.1) one sees that if the increase in the wage rate dominates the increase in the price index Switzerland's real income can actually rise.

I conclude by noting that Switzerland's gains from trade are mostly due to its neighbors as can be seen from the columns 2 and 3. However, columns 4 and 5 show that the losses from stoping to trade with a particular neighbors would be surprisingly small. The reason for this result is that I consider long-run effects, i.e. I allow the global industrial structure to fully adjust and only then I compare the resulting welfare levels. It is, of course, highly likely that this adjustment would be very painful and the associated welfare losses may be large compared to the long-run effect. In this sense this Section highlights the limitations of a static trade model for welfare analysis and puts for example the small gains from variety found in Broda and Weinstein (2006) in perspective.

4.6 Sensitivity: alternative parameters values

In this section I investigate the sensitivity of my main results with respect to the calibrated values of the elasticity of substitution, σ, factor shares, α, β, and γ, and the Pareto parameter θ. The elasticity of substitution governs the gains from variety. The lower the elasticity of substitution the higher the gains, i.e. the variance in income in the model is likely to increase with a lower σ. To get a lower bound for the elasticity of substitution I choose the lowest country specific median elasticity from Broda, Greenfield, and Weinstein (2006), which corresponds to the United Kingdom's median elasticity of 2.4. For an upper

Table 4.8: Sensitivity analysis: calibration results for alternative parameter values

changing parameter		% of the data's var (log (U))	change in var (log (U)) when... $f_n = \min\{f_n\}$	$d_{ni} = \text{mean}\,(d_{ni})_{i \neq n}$
α	0.25	93%	-16%	-13%
	0.50	137%	-8%	-11%
β	0.25	105%	-13%	-26%
	0.50	107%	-10%	3%
γ	0.70	126%	-14%	-14%
	0.85	74%	-9%	-10%
θ	3.60	103%	-8%	-7%
	8.28	109%	-16%	-21%
σ	2.40	119%	-20%	-23%
	5.80	96%	-0%	-1%

bound note that the elasticity of substitution is bounded from above by $\theta - \sigma + 1 > 0$, which must hold for the integral representing the price index to converge. For the baseline value of θ this yields an upper bound for σ of 5.8. Concerning the labor share most studies find shares of roughly two thirds. To check for the sensitivity of my model with respect to α I chose 0.5 as a lower bound and 0.75 as the upper bound. For β governing the intermediate share in the intermediate industry I take 0.5 from Alvarez and Lucas (2007) as an upper bound and choose 0.25 as the lower bound. For γ, which governs the intermediate share in final goods production I follow the deliberations by Alvarez and Lucas (2007) and use 0.7 as the lower bound and 0.85 as the upper bound. The Pareto parameter θ governs the elasticity of trade volumes with respect to trade costs. There is a relatively wide range of estimated values for the trade elasticity, which is discussed in Simonovska and Waugh (2010) in detail. I adapt the preferred estimate (8.28) from Eaton and Kortum (2002) as the high value and their low estimate of 3.6 as a lower bound.

Table 4.8 reports the corresponding calibration results. Column 3 reports the ratio of the models variance in log-real incomes relative to the variance in the data. The ratio varies between 74% and 137%. It is particularly sensitive to the capital share, α, and the elasticity of substitution, σ. Both parameters have effects that are reminiscent of the channel described in Mankiw, Romer, and Weil (1992). Columns 4 and 5 report how the results of two counterfactual experiments change with alternative parameters. The effect of giving all countries symmetric entry factor requirements is relatively stable across parameter values except for the high elasticity of substitution, whereas the effect of giving all country-pairs the same trade costs varies more. From these sensitivity results I take that the (modest) relevance of asymmetries in trade related elements for understanding inequality is mostly confirmed, but that the model outlined in this chapter would be too general for actual policy experiments.

4.7 Conclusions

This chapter developed a quantitative trade model that is adapted as a development accounting tool. The key ingredient of the trade model is an endogenous set of monopolistically competitive firms with heterogeneous productivities. The advantage of this setup compared to a Ricardian world of perfectly competitive firms is the possibility of allowing for fixed market entry costs. I estimated the trade costs by using data on the extensive margin and the aggregate value of trade flows and found that the fixed market entry costs are indeed negatively correlated with the observed real per capita incomes. In order to assess if this asymmetry across countries is an important contributor to between-country inequality I fully calibrate the model. The resulting quantitative model of the world economy captures the between-country inequality in income remarkably well. Using this model I perform a number of counterfactual experiments that demonstrate that asymmetries in the factor requirements associated with entering a market explain a modest amount of between country inequality - giving all countries the lowest estimated entry requirement reduces between-country inequality by 13%. Giving all country-pairs additionally the same trade costs leads to a total reduction of 23% of inequality. These effects are small compared to the reductions associated with equal capital endowments. However, they may be of interest to policy makers nevertheless since arguably entry regulations and tariffs are more straight forward to implement compared to measures targeting capital stock formation. In Section 4.5 I applied the model to locate the sources of Switzerland's gains from trade. The gains come mostly from close-by countries. It is remarkable that the compensating variation of Swiss consumers with respect to being allowed to trade with particular countries is surprisingly small due to reallocation effects that dampen the utility losses that emerge when a country disappears from the global trading network. A dynamic model of industry adjustment would help to investigate how much higher the welfare losses would be when explicitly considering the path of adjustment associated with the though experiments proposed in this chapter.

The equations that describe the equilibrium of the model developed in this chapter look very similar to the corresponding equilibrium conditions in a Ricardian model such as the one developed by Waugh (2010). I found that the two classes of models can deliver differing quantitative predictions even when changing common elements such as variable trade costs. The Ricardian framework is generally viewed as the less complicated model and thus often chosen for the sake of simplicity. The findings presented in Section 4.4.3 suggest that the more weight is given to the quantitative prediction of a model the more important it is to check the robustness of these predictions with respect to the market structure. In the light of these deliberations and the results of the sensitivity analysis a fruitful avenue for future research would be the development of hybrid models of international trade. Such a model could feature an elasticity of substitution within product categories that is different from the elasticity of substitution across products. Industries with high elasticities of substitution and low market entry costs then would resemble Ricardian industries, whereas other industries with low elasticities of substitution and high market entry costs would look more like the intermediate industry described in this chapter.

4.A Appendix

4.A.1 Deriving and characterizing the equilibrium

4.A.1.1 Bilateral cut-offs, z_{ni}^*

A country i firm with productivity z faces the following demand in country n

$$p_{ni}(z)\, x_{ni}(z) = X_n \left(\frac{p_{ni}(z)}{P_n}\right)^{1-\sigma},$$

where X_n is total intermediate absorption in country n and P_n represents the CES price index. It will be helpful later on to write the price index as a sum of supplying country-specific sub-indices,

$$P_n = \left(\sum_{i=1}^{N} P_{ni}^{1-\sigma}\right)^{1/(1-\sigma)},$$

where the sub-indices P_{ni} are defined by

$$P_{ni}^{1-\sigma} = \int_{\Omega_{ni}} p(j)^{1-\sigma}\, dj.$$

Given the isoelastic demand the optimal markup is constant and the optimal price that a country i producer with productivity z charges in market n is given by $p_{ni}(z) = (\sigma/(\sigma-1))\, c_i d_{ni}/z$. The corresponding operating profits are a constant fraction of revenue $\pi_{ni}(z) = p_{ni}(z)\, x_{ni}(z)/\sigma$. The cut-off firm has a zero contribution margin from entering market n, $\pi_{ni}(z_{ni}^*) = E_n$. Using the demand function and optimal pricing I can solve for the cutoff costs of serving country n, c_n^*, above which firms find it optimal not to enter market n

$$c_n^* = \frac{\sigma-1}{\sigma} P_n \left(\sigma \frac{E_n}{X_n}\right)^{\frac{1}{1-\sigma}}.$$

Note that the cutoff-costs depend only on country n-variables, i.e. all exporters have the same cutoff-costs of entering market n. The cutoff-productivities

$$z_{ni}^* = c_i d_{ni}/c_n^*$$

however differ across supplier countries due to differing trade and unit costs.

4.A.1.2 The price index, P_n, and its components, P_{ni}

Integrating the demand function over all productivities higher than the cutoff-productivity z^*_{ni} and divide by X_n reveals that the trade shares are proportional to the supplier country's relative contribution to the price index

$$\lambda_{ni} = \left(\frac{P_{ni}}{P_n}\right)^{1-\sigma}.$$

The more favorable an exporting country's prices are relative to all other prices in the destination market the higher the bilateral trade share λ_{ni}.

In order advance I write the bilateral component of the price index, $P_{ni}^{1-\sigma}$, as an average price of the varieties supplied by i in n weighted with the extensive margin of the trade flow from i to n

$$P_{ni}^{1-\sigma} = m_{ni} \int_{z^*_{ni}}^{\infty} p_{ni}(z)^{1-\sigma} \mu_{ni}(z)\, dz,$$

where $\mu_{ni}(z)$ is the pdf of the productivities of the producers in i conditional on entering n. I change variables from productivities to costs $c = c_i d_{ni}/z$ which yields

$$P_{ni}^{1-\sigma} = m_{ni} \int_{0}^{c_n} p_{ni}(c)^{1-\sigma} \mu_{ni}(c)\, dz.$$

To derive the specific expression for $\mu_{ni}(c)$ note first that the probability that a country i supplier is able to deliver to n at costs below c is given by

$$\Pr[C_{ni} < c] = \Pr[c_i d_{ni}/Z_i \leq c] = \Pr[c_i d_{ni}/c \leq Z_i] = T_i (c_i d_{ni}/c)^{-\theta}.$$

The cdf conditional on a producer actually entering, i.e. having a productivity that implies costs of supplying market i that are below the cutoff costs, c^*_n, is

$$\Pr[C < c | C \leq c^*_n] = (c^*_n/c)^{-\theta}.$$

The associated pdf is $\mu_{ni}(c)$. Therewith I can write the bilateral component of the price index as a function of the destination market cutoff c_n^* and the extensive margin of bilateral trade

$$P_{ni}^{1-\sigma} = (\sigma/(\sigma-1)\,c_n^*)^{1-\sigma}\,\theta/(\theta-\sigma+1)\,m_{ni}.$$

Adding up the bilateral components yield the actual price index in country n

$$P_n = \frac{\sigma}{\sigma-1}c_n^*\left(\frac{\theta}{\theta-\sigma+1}M_n\right)^{\frac{1}{1-\sigma}}.$$

4.A.1.3 Another expression for the trade share and total market entry costs

I plug the just derived bilateral component and the actual price index into above expression for the trade share to get

$$\lambda_{ni} = \frac{m_{ni}}{M_n}.$$

Moreover, substituting for the price index in the cut-off condition allows me to express the total costs that accrue from firms entering market n

$$E_n M_n = X_n \frac{\theta-\sigma+1}{\sigma\theta}. \tag{4.A.1}$$

Using this expression and the cut-off costs in above expression for the price index yields (4.2.2) of the main text.

4.A.1.4 Intermediate absorption

To derive a useful expression for a country's total intermediate absorption I start by noting that labor income in the competitive final goods sector is $w_i l_{F,i} = \gamma(1-\alpha)\,p_{F,i}y_{F,i}$. Market-clearing implies that all income of a country's agents is spent on (locally produced) final goods, $p_{F,i}y_{F,i} = w_i h_i \mathcal{P}_i + r_i K_i$. Due to the Cobb-Douglas technology I can write $p_{F,i}y_{F,i} = w_i h_i \mathcal{P}_i/(1-\alpha)$. Combing these deliberations yields the share of labor and capital that is employed in the final goods sector, $\gamma = l_{F,i}/(h_i\mathcal{P}_i) = k_{F,i}/K_i$. Since final goods production is perfectly competitive γ percent of total revenue in the final goods sector is paid to pay labor and capital and the remaining $(1-\gamma)$ percent of revenue is used to buy intermediate inputs

$$Q_{F,i} = (1-\gamma)\frac{w_i h_i \mathcal{P}_i}{1-\alpha}.$$

To derive the value of intermediate inputs used in intermediate production I write a firm's variable cost, $cost(z)$, as a constant fraction of revenue $r(z)$, $cost(z) = r(z)(\sigma-1)/\sigma$. $(1-\beta)$ percent of the cost are used to cover intermediate expenses. Thus, a country i firm with productivity z_i's total intermediate demand (in value terms) is given by $P_i q(z_i) = (1-\beta) r(z_i)(\sigma-1)/\sigma$. Integrating over all active producers yields $Q_{I,i} = (1-\beta)(\sigma-1)/\sigma R_i$, where R_i is total revenue in country i's the intermediate sector. Balanced trade implies $R_i = X_i$,[14] so that we can write

$$Q_{I,i} = (1-\beta)\frac{\sigma-1}{\sigma}X_i.$$

Since intermediates are only used in production market clearing requires $X_n = Q_{I,i} + Q_{F,i}$. Substituting for $Q_{F,i}$ and $Q_{I,i}$ allows me to solve for country i's intermediate absorption

$$X_n = \frac{\sigma(1-\gamma)}{(1+\beta(\sigma-1))(1-\alpha)} w_n h_n \mathcal{P}_n. \tag{4.A.2}$$

A country's total intermediate absorption is thus a constant fraction of its total labor income.

4.A.1.5 Number of entrants

In the following I derive an expression for the measure of entrants in country i, $\mathcal{N}_i$, i.e. the measure of firms that pay the setup costs. For that I define Π_n as the total profits that accrue from sales in market n. They equal operating profits X_n/σ minus aggregate market entry costs $E_n M_n$, i.e.

$$\Pi_n = X_n/\sigma - E_n M_n = X_n(\sigma-1)/(\sigma\theta).$$

[14]Country i's trade balance is $\sum_{n\neq i} X_{ni} = \sum_{k\neq i} X_{ik}$. Adding the value of the home supply, X_{ii}, on both sides yields $R_i = \sum_{n=1}^{N} X_{ni} = \sum_{k=1}^{N} X_{ik} = X_i$.

Given the Pareto distribution the level of costs (and therefore prices) do not bear any information about the source country. Therefore the profits are split among the supplier countries in proportion to the trade shares λ_{ni}. Free entry thus requires that total set-up costs in i equal total profits made by active firms $\sum_{n=1}^{N} \lambda_{ni}\Pi_n$. Note that by imposing balanced trade the total profits can be written as $(\sigma-1)/(\sigma\theta)\,X_i$. The total setup costs in country i are given by $\mathcal{N}_i f_i^e w_i^{1-\alpha} r_i^{\alpha} = \mathcal{N}_i f_i^e w_i \left(\alpha/(1-\alpha)\right)^{\alpha} (h/k)^{\alpha}$, where the second expression follows from market clearing in the non-tradable factors. Equating total setup costs and with total profits made by active firms allows me to solve for the measure of entrants $\mathcal{N}_i$ as a function of exogenous variables

$$\mathcal{N}_i = \frac{(\sigma-1)(1-\gamma)}{\theta(1+\beta(\sigma-1))}\frac{1}{f_i^e}\mathcal{P}_i k_i^{\alpha} h_i^{1-\alpha}. \tag{4.A.3}$$

4.A.1.6 Real per capita incomes

Country n's real per capita income is

$$U_n = \frac{y_{F,n}}{\mathcal{P}_n} = \frac{r_n k_n + w_n h_n}{p_{F,n}} = \frac{w_n h_n/(1-\alpha)}{p_{F,n}}.$$

The unit costs in the final goods sector are (ignoring constants)

$$p_{F,n} = \left(r_n^{\alpha} w_n^{1-\alpha}\right)^{\gamma} P_n^{1-\gamma}.$$

Using this together with $r^{\alpha}w^{1-\alpha} = \left(\alpha/(1-\alpha)\right)^{\alpha}(h_n/k_n)^{\alpha} w_n$ allows me to write the real income (ignoring an irrelevant multiplicative constants) as

$$U_n = \left(\frac{w_n}{P_n}\right)^{1-\gamma} k_n^{\alpha\gamma} h_n^{1-\alpha\gamma}.$$

To derive (4.4.1) note that a country n's home share is

$$\lambda_{nn} = \frac{\widetilde{T}_n \left(w_n^{\beta} P_n^{1-\beta}\right)^{-\theta}}{\sum_{k=1}^{N} \widetilde{T}_k \left(w_k^{\beta} P_k^{1-} d_{nk}\right)^{-\theta}}.$$

Using equation (4.2.2) we can substitute for the sum in the denominator

$$\lambda_{nn} = \left(\frac{f_n}{(K_n)^{\alpha} (h_n \mathcal{P}_n)^{1-\alpha}} \right)^{-\frac{1-\sigma+\theta}{(\sigma-1)}} \widetilde{T}_n \left(\frac{w_n}{P_n} \right)^{-\beta\theta}.$$

Rearranging and substituting for $\widetilde{T}_n$ then yields

$$\frac{w_n}{P_n} = (\lambda_{nn})^{-\frac{1}{\beta\theta}} (f_n)^{-\frac{1-\sigma+\theta}{(\sigma-1)\beta\theta}} \left((K_n)^{\alpha} (h_n P_n)^{1-\alpha} \right)^{\frac{\theta}{\beta(\sigma-1)}} \left(\frac{T_n}{f_n^e} \right)^{\frac{1}{\beta\theta}} (h_n/k_n)^{-\alpha}.$$

Inserting this into (4.2.1) and then into the expression for real income we get (4.4.1) .

4.A.2 An alternative approach to calibrating the technologies

Instead of imposing market clearing to recover the technologies one can follow Waugh (2010) and use the country effects $S_i = \log\left(\widetilde{T}_i \left(w_i^{\beta} P_i^{1-\beta} \right)^{-\theta} \right)$ estimated in the gravity equation, $\widehat{S}_i$. Based on these I then compute the implied price indices

$$\widehat{P}_n = (M_n)^{\frac{1}{\theta}+\frac{1}{1-\sigma}} \left(\sum_{k=1}^{N} \exp\left(\widehat{S}_k\right) d_{nk}^{-\theta} \right)^{-\frac{1}{\theta}}.$$

The correlation between the thus obtained price indices and the equilibrium price indices that follow from the approach in the main text is very high with 0.93. Using these price indices, the estimated country, and the wage rates I can then solve for the implied reduced form technologies,

$$\widehat{T}_i = \left(w_i^{\beta} \widehat{P}_i^{1-\beta} \right)^{\theta} \exp\left(\widehat{S}_i\right).$$

The correlation between these technologies and the one obtained in the main text is high as well with 0.91.

4.A.3 The Ricardian analogue (Waugh, 2010)

In this appendix I outline the Ricardian model proposed by Waugh (2010) and highlight some of the differences and commonalities. Similar to the model in the main text the world consists of N countries. Country i is inhabited by a measure $\mathcal{P}_i$ homogeneous agents, each endowed with h_i efficiency units of labor (human capital) and k_i units of capital. Labor and capital are internationally immobile, but perfectly mobile within countries. There are two industries. The final goods industry produces a homogeneous non-tradable consumption good using a CRS technology

$$y_F = \left(k_F^{\alpha} l_F^{1-\alpha}\right)^{\gamma} q_F^{1-\gamma},$$

whereas the *competitive* intermediate goods industry produces tradable, differentiated intermediate goods using the following production function

$$y\left(z\left(j\right)\right) = z\left(k\left(z\right)^{\alpha} l\left(z\right)^{1-\alpha}\right)^{\beta} q\left(z\right)^{1-\beta}.$$

$z\left(j\right)$ is a country-variety specific and modeled as a draw from a country-specific Fréchet distribution

$$F_n\left(z\right) = \Pr\left[Z_n\left(j\right) \leq z\right] = \exp\left\{-T_i z^{-\theta}\right\}.$$

Trade is costly in the sense of bilateral iceberg trade costs, d_{ni}. However, there are no fixed market entry costs.

Given these assumptions the equilibrium is characterized by a market clearing condition

$$w_i = \sum_{n=1}^{N} \lambda_{ni} \frac{h_n \mathcal{P}_n}{h_i \mathcal{P}_i} w_n,$$

where the bilateral trade shares are

$$\lambda_{ni} = \frac{\widetilde{T}_i \left(w_i^{\beta} P_i^{1-\beta} d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} \widetilde{T}_k \left(w_k^{\beta} P_k^{1-\beta} d_{nk}\right)^{-\theta}}.$$

In the Ricardian setup $\widetilde{T}_i$ has a different interpretation

$$\widetilde{T}_i = \left(h_i / k_i\right)^{-\alpha\beta\theta} T_i$$

and the price index does not depend on market entry costs

$$P_n = \left(\sum_{i=1}^{N} \widetilde{T}_i \left(w_i^{\beta} P_i^{1-\beta} d_{ni} \right)^{-\theta} \right)^{-\frac{1}{\theta}}.$$

In the main text I investigate how these differences affect the quantitative behavior of the models. It is straight forward to adapt the quantification strategy outlined in the main text to this model.

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